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RESULTS OF BENTHIC STUDIES AT CHALK POINT

Final Report to the Maryland
Power Plant Siting Program

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ABSTRACT

Field studies to assess the effects of power plant operations at the Chalk Point Steam Electric Station on benthic communities were conducted in the Patuxent estuary between April 1978 and May 1980. The studies did not indicate that plant operations affected the regional distributions of species composing macrobenthic communities or their biomass. However, total macrobenthic densities, primarily due to high densities of two oligochaete species, were four to ten times higher in the thermally affected region than at reference sampling sites in the Patuxent or in environmentally similar regions of the Chesapeake Bay. The unusually high oligochaete densities were not due to variation in natural environmental factors and were attributed to power plant operations. The exact mechanism of this enhancement is not understood, but there is little doubt it is related to plant operations, probably due to organic enrichment from planktonic entrainment mortalities combined with higher temperature. No power plant effects on meiobenthic or microbenthic organisms were detected in the nearfield. Power plant operations at Chalk Point thus did not adversely affect any species.

FOREWORD

This report summarizes the findings of benthic studies conducted at the Chalk Point Steam Electric Station (SES) for the Power Plant Siting Program (PPSP) of the Maryland Department of Natural Resources (MDNR) from 1978 through 1980. These studies were conducted under contracts P1-72-08(78), P2-72-02(78), P1-72-01(79), P2-72-02(79), P1-72-01(80), and P2-72-02(80), by the Environmental Center of Martin Marietta Corporation and the Chesapeake Biological Laboratory of the University of Maryland's Center for Environmental and Estuarine Studies.

This report is organized in the following manner:

- An executive summary that discusses the major findings
- An introductory section that provides relevant historical background information, defines the objectives and scope of the Patuxent benthic program, and provides a general discussion of benthic ecology
- A section that describes the site characteristics, the plant characteristics, and modes of interactions between benthic organisms and plant operations likely to be of major concern
- A study methods section that details the sampling and analysis methods
- A results section that presents the major findings, defines the impacts of power plant operations at Chalk Point on benthic organisms, and recommends future informational needs
- A section containing all tables
- A section containing all figures
- A list of references
- A tabular summary of biological information on benthic species collected in the Patuxent estuary (Appendix A)
- A tabular summary of physical, chemical, and biological data collected during 1979-1980 (Appendix B).

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I. EXECUTIVE SUMMARY

Since 1978, the Power Plant Siting Program (PPSP) of Maryland's Department of Natural Resources has funded a benthic program in the Patuxent estuary to assess the effects of power plant operations at Chalk Point on the estuary's benthic resources. The major findings of the work completed to date are summarized below.

The region of the Patuxent where benthic studies were conducted has three major salinity zones that are characteristic of estuaries: tidal freshwater (0 to 0.5 ppt), oligohaline (0.5 to 5 ppt), and mesohaline (5 to 18 ppt). The position of each of these zones in the estuary varied with changes in river flow. Salinities were generally lowest in winter and spring during periods of high runoff and rainfall; they were highest in summer and fall during periods of low runoff and rainfall. However, over the study period, flow conditions in the Patuxent varied out of phase with season (e.g., during the unusually wet summer and fall of 1979, fall salinity distributions in the Patuxent were similar to what would generally be expected during spring). The transition zone between oligohaline and mesohaline salinities during periods of high runoff was just below the plant site at Benedict Bridge. During periods of low runoff, this transition zone was approximately 20 km upstream of the plant site, near Jones Point. Salinities at the power plant were thus typically oligohaline during spring and winter (high runoff) and mesohaline during summer and fall (low runoff).

Salinities in the discharge area were frequently 1 to 3 ppt lower than salinities at downstream reference locations. Salinity differences of this magnitude in the oligohaline-mesohaline transition zone could affect the

standing stock size of some benthic organisms. Thus, natural differences in benthic community characteristics resulting from natural salinity variations could obscure plant-induced changes.

In fall, the Bay and the relatively deep mesohaline portion of the Patuxent responded to cooling air temperatures more slowly than the shallow, tidal freshwater and oligohaline regions. As a result, water temperatures increased from upstream to downstream during fall. In spring, the reverse occurred. Longitudinal temperature gradients were not present during summer or winter.

The size of the region affected by thermal discharges from the Chalk Point power plant varied with tidal stage, meteorological conditions, river flow, and plant-operating conditions. At 50% of allowable plant capacity (two units operating at 250 MWe each), the area experiencing 1°C or more excess temperatures extended from 6 km upstream to 6 km downstream of the point where cooling waters were returned to the estuary. The highest above-ambient temperatures occurred on the western shore between the channel and the shoreline, over a region approximately 2 km upstream and 2 km downstream of the terminus of the discharge canal. When discharge waters were more saline (i.e., denser) than the estuarine receiving waters, the discharge plume sank, and measurable excess temperatures 1°C or more above ambient occurred throughout the water column and contacted the bottom over a region approximately 1 km upstream or downstream of the discharge canal terminus. When averaged over a tidal cycle, the area of bottom exposed to excess temperatures 2°C or more above ambient was about 275 hectares. Thus, the discharge of heated water by the Chalk Point SES influenced a large region of

the Patuxent estuary where benthic standing stocks were already strongly influenced by a natural salinity gradient.

Dissolved oxygen levels along the Patuxent estuary were controlled by seasonal changes in temperature, biological activity, and freshwater inflow. Dissolved oxygen levels were highest in winter when water temperatures and biological activity were low and freshwater flows were typically high. In summer, when conditions were the reverse, dissolved oxygen levels were lowest. Summer dissolved oxygen values were frequently less than 75% of saturation above the Benedict Bridge (upper mesohaline to tidal freshwater habitats). Upstream organic and nutrient inputs probably cause the longitudinal dissolved oxygen gradient characteristic of the Patuxent estuary during summer. Station-to-station variations in dissolved oxygen concentration were small, and power plant operations did not appear to have any measurable effects on dissolved oxygen levels in the nearfield region.

All sites for sampling the macrobenthic community were at a depth of approximately 3 m and had similar substrate characteristics (except possibly near Sheridan Point). Sediments at the nearfield and most other sample sites were muddy ($> 90\%$ silts and clays) and had a relatively high organic content ($\approx 10\%$ total organic carbon content and 1 to 2% available carbon content). Thus, spatial and temporal variations in substrate characteristics were not likely to result in large station-to-station variations in benthic community characteristics. Plant discharge velocities were low (≈ 0.3 m/s) and did not significantly or noticeably alter the characteristics of bottom sediments in the discharge region.

Longitudinal variation in physical/chemical factors along the Patuxent were frequently interrelated. For example, spatial variations in salinity

were significantly correlated with changes in sediment characteristics, and the longitudinal patterns in carbon content of sediments were similar to longitudinal patterns in dissolved oxygen levels. Survey data on biological and physical/chemical factors at reference locations far upstream and far downstream of the discharge site were used in conjunction with multiple regression and analysis of covariance techniques to account for changes in benthic community characteristics due to longitudinal variations in the factors. Then, power plant effects on benthic community characteristics were assessed separately. This analytical approach should provide a rigorous assessment of power plant effects.

The species composition and number of species in communities of macrobenthos (organisms > 0.5 mm) along the Patuxent were similar to those in other tributaries of the Chesapeake Bay and in other temperate-zone estuaries. There was no indication that power plant operations at the Chalk Point SES affected the regional distribution of species or the number of species. However, indices of species diversity suggested that power plant operations affected the distribution of individuals among the component species in an area that extended approximately 1 to 2 km above and below the terminus of the discharge canal.

Total macrobenthic densities (primarily two oligochaete species) were 4 to 10 times higher in the immediate discharge region of the Chalk Point SES than at other sampling sites in the Patuxent estuary or in environmentally similar regions of the Chesapeake Bay. These unusually high densities could not be attributed to natural factors and were thus attributed to power plant operations.

Large localized standing stocks of oligochaetes are generally associated with high bacterial productivity or densities, a condition that accompanies organic and nutrient enrichment. However, the organic content and ATP levels in sediments in the discharge region were not higher than at upstream or downstream reference sites before or after adjustments for salinity and mechanical properties. Therefore, reasons for the high abundances of oligochaetes in the discharge region are only tentative. They could be related to the excess temperatures and/or possibly to organic enrichment from plankton killed through entrainment that was rapidly used by benthos before bacterial standing stocks or productivity could increase.

The biomass of macrobenthic organisms in the Patuxent was similar to that in other tributaries of the Chesapeake and in other temperate-zone estuaries where large clams are a numerically dominant benthic organisms. Because oligochaetes are very small, increases in their density in the discharge region resulted in no detectable influence on macrobenthic biomass. The spatial distribution of macrobenthic biomass in the Patuxent was largely controlled by salinity.

We found no evidence that power plant operations at Chalk Point affected the stock size or productivity of macrobenthic species other than oligochaetes. Furthermore, pollutant-tolerant macrobenthic species in the tidal freshwater regions sampled did not appear to respond to organic and nutrient enrichment from upstream sources. (However, note that our sampling program was limited to regions of the Patuxent downstream of Western Branch.)

Seasonal variations in the stock size of many macrobenthic species were not of the magnitude reported for the main stem of the Chesapeake Bay but were similar to those reported for low salinity areas of other Bay tributaries.

Temporal trends for benthic community characteristics (e.g., standing stock size) in the discharge region and downstream reference areas were generally similar, suggesting that there were no major power plant effects on all benthic community characteristics and that temporal patterns were similar at affected and reference stations.

Density and biomass of the clam, Macoma balthica, increased in an upstream direction and were maximum near the area experiencing maximum exposure to excess temperatures from plant operations. However, M. balthica were more dense and abundant in this region before power plant operations began. The larger stock size near the discharge site was due to the effects of salinity on recruitment, growth, and mortality rates of this species.

The spatial distributions of meiobenthos (organisms < 0.5 mm but > 63 μ m) in the Patuxent estuary were primarily controlled by salinity and sediment characteristics. Meiobenthic stocks were smaller during the July 1979 survey than expected from surveys of similar habitats in other estuaries. Winter stocks in the Patuxent were roughly equivalent to those reported for similar habitats. After adjustment for spatial variation due to natural factors, we found no evidence that power plant operations or organic and nutrient enrichment from upstream sources were affecting meiobenthic distributions in the Chalk Point region of the Patuxent. This observation does not preclude the possibility that these factors could enhance meiobenthic productivity and energy flow without measurably increasing stock size.

The spatial distribution of microbenthos (organisms < 63 μ m) along the Patuxent, as indicated by ATP levels in sediments, was also primarily controlled by prevailing salinity patterns and the influence of salinity on the silt-clay and carbon content of sediments. Organic or nutrient inputs from upstream

sources or the Chalk Point power plant did not appear to affect the standing stock size of the microbenthos near the plant site. This observation does not preclude the possibility that power plant operations or upstream organic and nutrient inputs could enhance microbenthic productivity and energy flow without measurably increasing stock size.

Field predator exclusion experiments, which were designed to determine the effects of predation on Patuxent benthic populations and community characteristics, indicated that predators were not a major factor controlling benthic stock sizes. Predation also did not have a large effect on meiobenthic or macrobenthic recolonization. However, benthic organisms were the major type of food observed in the stomachs of demersal fish. We are not sure of all the reasons for these results. However, predator standing stocks were low relative to benthic standing stocks, and thus, low predation intensity may have been a contributing factor. The timing of these experiments turned out to be poor. During spring and summer, which are normally ideal times to conduct predator exclusion experiments, we were unable to exclude the abundant small predator crabs from the experimental sites. This made it necessary to conduct the experiments in fall and winter when abundances of large bottom feeding fish and crabs were low and benthic reproductive activity was not high. Thus, it appears predator exclusion experiments in the Chalk Point region are not likely to provide useful results.

Essentially no macrobenthic organisms lived in the discharge canal during warm months when temperatures were maximum and chlorine was being used to prevent the growth of fouling organisms on condenser tubes in the plant. During cooler periods, macrobenthic organisms rapidly recolonized the canal but never attained the densities observed in comparable habitats

in the adjacent estuary. Experiments comparing recolonization processes in discharge canal sediments and natural estuarine sediments demonstrated that spring and summer conditions in the canal retarded macrobenthic and meiobenthic recolonization processes there. Only three macrobenthic taxa (Nereis succinea, Limnodrilus hoffmeisteri, and larvae of the insect family Tenebrionidae) had higher recolonization rates in the canal than in the estuary. These taxa are known to be opportunistic organisms that rapidly colonize available habitats in even the most rigorous estuarine environments. When discharge canal sediments (which could possibly contain toxic chemicals and metals) were moved to the adjacent estuary, they were not toxic to benthic organisms and were colonized at the same rate and in the same patterns as natural estuarine sediments, given the range of natural variation expected during our experiments.

The response pattern of the Patuxent benthic communities to organic enrichment at levels similar to those resulting from entrainment mortalities was evaluated experimentally by organically enriching bottom sediments with an organic fertilizer. Enrichment resulted in increased standing stock sizes of several deposit feeding species. This result supported our speculations that organic enrichment from entrainment mortalities was a factor that may be contributing to higher than expected standing stocks of deposit feeders near some power plant discharges.

On the basis of the findings presented in this report, we suggest that power plant operations at Chalk Point have not adversely affected any benthic organisms, but has favored populations of two oligochaete species in the discharge region. Although the exact mechanism of this enhancement is not

understood, there appears to be little doubt it is related to plant operations, probably from organic enrichment due to entrainment mortalities and from higher temperatures. Because oligochaetes are not generally considered to be food organisms for bottom feeding predators and can rework large volumes of bottom sediments, the higher abundances of these organisms at the discharge site could increase the levels of nutrients and other chemicals in the water column. Oligochaetes could be considered nuisance species.



II. INTRODUCTION

A. BACKGROUND AND PROBLEM DEFINITION

Since the mid 1960's, Potomac Electric Power Company (PEPCO) has operated a fossil-fueled power generation station near Chalk Point on the Patuxent estuary. It is the only power plant on the Patuxent, and its operation has caused controversy among environmentalists, resource managers, regional planners, the utility, and interested citizens (see, e.g., Mihursky 1969; Mihursky and Boynton 1979). Numerous monitoring surveys and experimental studies have been conducted by state, federal, industrial, and educational organizations to investigate potential power plant-induced changes in physical, chemical, and biological characteristics of the adjacent estuarine ecosystem. Plant operations had relatively large effects on the physical and chemical environment and caused large losses to nearfield populations of aquatic organisms pumped through the plant with intake flows (entrainment) or trapped on intake structures (impingement).

However, only relatively minor changes in nearfield populations have been attributed to plant operations. Probably the major reason nearfield effects were not detected was that the experimental designs used by most of the field programs conducted at the Chalk Point SES prior to 1977 did not account for variations in nearfield populations due to salinity fluctuations or urban development. Salinity is the major environmental factor controlling the spatial and temporal distribution of estuarine populations and caused natural, large population shifts near the site of the Chalk Point power plant (Lippson et al. 1979). Urban development in the upper Patuxent watershed during the 1960's and 1970's caused substantial changes in nutrient levels, primary

productivity, turbidity, and dissolved oxygen concentrations in the Chalk Point region, possibly affecting the abundance and distribution of estuarine populations in the discharge site independent of plant operations (Mihursky and Boynton 1979).

To rigorously assess power plant effects at Chalk Point, one must first quantify the effects that natural salinity gradients and upstream development have on the estuarine biota. Using the findings of historical studies as a basis, the Power Plant Siting Program (PPSP) and PEPCO sponsored a broad spectrum of field programs from 1976 through 1979 that were designed to partition power plant effects from other sources of variation, including the salinity gradient and urban development. The PEPCO-sponsored studies were carried out mainly by their contractor, the Academy of Natural Sciences of Philadelphia (ANSP), and concentrated on quantifying nearfield and in-plant effects. The PPSP-sponsored studies were carried out by a variety of contractors and were coordinated by the Environmental Center (EC) of Martin Marietta Corporation. These studies were designed to place PEPCO's nearfield and in-plant studies into a regional perspective, as well as to supplement and support ANSP's nearfield findings.

As part of PPSP's Patuxent field program, a benthic community study was initiated in April 1978. The specific objectives were to:

- Determine the environmental factors controlling the spatial and temporal distribution of benthic organisms in the Patuxent estuary so that natural variation in population and community characteristics could be separated from changes in these parameters due to power plant operations
- Determine the effects of power plant operations on physical and chemical factors that affect the distribution of benthic organisms
- Determine the effects of power plant operations on benthic community characteristics (e.g., standing stock size)

- Determine the effects of power plant operations on size, age class structure, and growth of populations of the representative important clam species, Macoma balthica
- Determine the importance of bottom-feeding finfish and crabs in controlling population and community characteristics of macrobenthic communities
- Determine the importance of organic inputs in controlling benthic community characteristics
- Determine if discharge canal sediments or some component of them were toxic to estuarine organisms
- Determine the comparability of the macrobenthic population and community data gathered during this study to data gathered from similar habitats in other parts of the Chesapeake Bay and to other benthic data gathered at the Chalk Point site
- Provide basic biological information on benthic resources of the Patuxent estuary to supplement the Water Resources Administration's (WRA) Patuxent studies
- Determine the effects of urban development on the benthos of the estuarine region of the Patuxent.

To accomplish the above objectives, a variety of benthic field projects were conducted. The results are summarized in Section I (Executive Summary). Section III (Characterization of Study Area and Chalk Point SES) discusses the site and plant characteristics that are important for understanding the study design and experimental methods used. Section III also discusses the major interactions likely to occur between benthic organisms and power plant operations. The mechanics of the benthic studies are presented in Section IV (Study Methods). Detailed findings and analytical results are presented in Section V (Results).

B. BENTHIC BIOTA

Benthic communities are important structural and functional components of estuarine ecosystems, with benthic respiration generally accounting for a

significant portion of total ecosystem metabolism (Carriker 1967; Hale 1974; Rhoads 1974; Osborne et al. 1979). Energy inputs to benthic communities primarily come from organic materials that settle from the water to the bottom. These materials include detritus from marsh grass and phytoplankton, fecal materials, and the remains of dead zooplankton and nekton. The microbenthos (organisms smaller than 63 μm , including bacteria, fungi, and protozoans) are the initial colonizers and decomposers of newly settled organic materials. The microbenthos, in turn, serve as the primary food for the larger meiobenthos (organisms larger than 63 μm but smaller than 0.5 mm, including harpacticoid copepods and nematodes) and macrobenthos (organisms larger than 0.5 mm, including segmented worms, clams, and oysters). These larger benthic organisms are eaten by fish, birds, and crabs, as well as by man (Chao and Musick 1977; Virnstein 1977; Homer and Boynton 1978; Holland et al. 1980b). At each level of this cycle, organic materials are transferred through the ecosystem, and inorganic nutrients are returned to the water to be used again (Lippson et al. 1979).

In the Chesapeake Bay, primary factors controlling spatial distributions and structural characteristics of macrobenthic populations and communities (i.e., standing stocks as well as the kinds and relative abundances of organisms) are salinity, currents, substrate characteristics, dissolved oxygen concentration, and the quality and quantity of food settling to the bottom (see, e.g., Lippson et al. 1979). Primary factors controlling temporal variation of macrobenthic populations and communities are predation by seasonally abundant finfish and crabs, temperature through its effect on reproductive activity, and seasonal or longer-term variations in salinity (Holland et al. 1980b). It is possible to quantify and account for variations in macrobenthic community characteristics resulting from most of these natural factors.

Thus, changes in macrobenthic population and community characteristics due to power plant operations can be separated from natural variation, providing for a rigorous assessment of power plant effects. Furthermore, because the macrobenthos form direct links to primary decomposers, primary producers, and top level predators, any assessment of their state or condition should also be an assessment of the state of the entire ecosystem.

Factors controlling spatial and temporal distribution of meiobenthic and microbenthic population and community characteristics have not been studied in the Maryland portion of the Chesapeake Bay. However, since the available literature suggests that factors controlling their distribution should be similar to those affecting the macrobenthos (e.g., Coull 1975), it should also be possible to use changes in their population and community characteristics as indicators of plant effects.

Separation of natural variations from power plant-induced changes in benthic population and community characteristics requires relatively detailed and comprehensive baseline information on environmental factors controlling natural distributional patterns. Because such comprehensive baseline information was not available for the Patuxent estuary prior to this study, we had to gather information on natural spatial and temporal distribution patterns, dominant species, community complexity, and factors controlling natural distribution patterns (including the effects of urban development) while we assessed the effects of plant operations. Since salinity variation in the Patuxent, especially in the Chalk Point region, can be relatively large and at times can fluctuate through ranges known to be physiologically limiting to many benthic species, we anticipated that it would be particularly difficult to partition power plant effects on community characteristics from natural variations due to salinity.

Preoperational data were available for the Patuxent on the population characteristics of the clam, Macoma balthica. This clam is a structurally important component of benthic communities in the Patuxent because it is a relatively abundant, large organism that frequently composes the majority of the benthic biomass (e.g., McErlean 1964). It is also a functionally important component of the benthos because it is a major food item in the diets of finfish and waterfowl (Lippson et al. 1979). Because of its important ecological role, Maryland water quality regulations governing thermal discharges and 316 demonstrations (COMAR 08.05.04.13) include M. balthica on their list of species whose population characteristics could potentially serve as indicators of changes in water quality (i.e., representative and important species). Therefore, a study of the population characteristics of M. balthica was included in the PPSP Patuxent benthic program.

III. CHARACTERIZATION OF STUDY AREA AND CHALK POINT SES

A. SITE CHARACTERISTICS

The Patuxent watershed includes parts of Anne Arundel, Howard, Montgomery, Prince Georges, Calvert, Charles, and St. Marys counties, Maryland, and covers approximately 2,230 km². The river is approximately 175 km in length and ranks sixth in volume (7.5×10^8 m³) among the tributaries of the Chesapeake Bay (Unger et al. 1978). The lower 60 km of the Patuxent are under tidal influence, with salt water penetrating approximately 50 km upstream depending on the magnitude of freshwater flows. Mean river discharge in the vicinity of the Chalk Point SES is 20 m³/s during spring and approximately 8 m³/s during fall.

Below the Benedict Bridge, the Patuxent estuary is relatively wide and deep (Figure 1). Its normal two-layered circulation pattern is sometimes modified by the geomorphology of the estuary near its mouth, causing a three-layered pattern near Solomon's Island (Owens 1969).

The upper portion of the Patuxent estuary (above the Benedict Bridge) is relatively shallow and turbid. Here, the estuary is bounded by extensive marshlands (about 33 km²), woodlands, and agricultural fields (Unger et al. 1978), and the water column is generally well-mixed. Salinity varies seasonally and from year to year depending on the magnitude of freshwater runoff from the watershed, and responds quickly to local and regional changes in runoff. In the wide, lower regions of the Patuxent, salinity patterns are more stable and do not respond quickly to local changes in runoff.

At the site of the Chalk Point SES, which is just above the Benedict Bridge, salinities are generally lowest (2 through 6 ppt) in spring and highest

(6 through 15 ppt) in fall (Flemer et al. 1970; Lacy and Krueger 1978a, 1978b, 1979). Temperature varies annually from 0°C to 30°C. Seston concentration varies from 10 mg per liter to 100 mg per liter (Flemer et al. 1970). Tidal excursion distance varies from location to location, but generally averages about 5 km. Circulation patterns are complex. At low flows, nontidal currents are strongly influenced by meteorological conditions in the main stem of the Chesapeake Bay (Polgar et al. 1980).

The Patuxent receives a high load of suspended sediment from its headwaters (Keefe et al. 1976). Discharge for a one-year period in 1968 and 1969 was 21×10^3 metric tons of suspended sediment in $326 \times 10^6 \text{ m}^3$ of water, while for a one-year period in 1969 and 1970 it was 32×10^3 metric tons of sediment in $422 \times 10^6 \text{ m}^3$ of water. Per square kilometer of drainage area, this rate is almost three times greater than that of a comparable portion of the Susquehanna River. Most of the suspended sediment discharged into the Patuxent is deposited in the tidal freshwater and oligohaline regions between Nottingham and the Benedict Bridge (just upstream of the Chalk Point power plant).

Longitudinal substrate characteristics and sedimentation processes of the Patuxent have not been studied in detail, but sedimentation rates are known to be high (Keefe et al. 1976). In the lower part of the estuary, nearshore sediments are generally a mixture of sand and mud, while channel areas are generally muds. In the upper part of the estuary, especially upstream of Trent Hall Point (Figure 1), sediments are almost all muds and contain relatively high levels of organic materials (Holland et al. 1980a). Occasional nearshore habitats in the upper reaches of the estuary consist of sandy sediments, which contain larger quantities of silts, clays, and organic materials

than sandy habitats of the lower Patuxent or the Chesapeake Bay (Holland et al. 1978). Scattered oyster bars and shell deposits occur near Potts Point and the Benedict Bridge (Figure 1), but shell habitats are generally more common in the higher salinity regions of the estuary near Solomons.

B. PLANT CHARACTERISTICS

The Chalk Point SES began operating in 1964 and has a rated generating capacity of 1,312 MWe: two units with once-through cooling rated at 355 MWe each, and one unit with a cooling tower rated at 602 MWe. At the present time, there is a 500 MWe limitation on the operations of the two once-through units because of air quality regulations. The once-through units each draw approximately $15 \text{ m}^3/\text{s}$ of water from Swanson Creek through a dredged intake canal (Figure 2). The water is discharged approximately 3 km upstream, near Potts Point, after passing through a dredged canal that uses a slow-moving discharge system ($\approx 0.3 \text{ m/s}$). Transit time for a particle through the canal is approximately two hours. Sediments on the bottom of the discharge canal are generally muds, except for one patch of muddy-sand near the middle. There is also a small region of shell mixed with mud near the terminus. The sides of the discharge canal are lined with coarse sand and shell.

Traveling screens, covered with 1-cm^2 wire mesh, are in front of each condenser intake to prevent debris and large organisms (e.g., blue crabs and fish) from being drawn into the plant with intake flows. Traveling screens are rotated and cleaned of debris and organisms three times per day at approximately 8-hour intervals. Augmentation pumps, which withdraw additional water at $15 \text{ m}^3/\text{s}$ from the intake region and discharge it directly into the head of the discharge canal, operate occasionally during summer and early fall to

reduce the ΔT of discharge water. The intakes to the augmentation pumps are not protected by screens. When water temperatures are above 10°C, chlorine is continuously injected behind the traveling screens and in front of the condensers to prevent biofouling of the plant's internal structures.

Results of a dye study conducted in 1979 indicate that recirculation of discharge water into intake flows can be as high as 20 to 30 percent (Binkerd et al. 1980). Furthermore, the complex circulation pattern characteristic of the Chalk Point region could enhance recirculation during low flow periods and under some meteorological conditions (Polgar et al. 1980).

The internal surfaces of the cooling tower at Chalk Point are periodically cleaned with a variety of agents. Residuals from these cleaning agents, which contain a number of heavy metals and detergents, are discharged into a series of holding and treatment ponds adjacent to the discharge canal. Irregularly, overflows and possibly some drainage from the ponds empty into the discharge canal.

C. INTERACTIONS BETWEEN BENTHIC ORGANISMS AND PLANT OPERATIONS

Figure 2 diagrams the path of cooling water flow through the Chalk Point SES and identifies sites where benthic organisms could interact with plant operations. Table 1 summarizes the major interactions likely to occur between benthic organisms and the Chalk Point power plant.

Benthic organisms that are taken into the intake embayment with intake flows may become trapped there ("entrapped"). Those larger than 1 cm (blue crabs) may be trapped on the intake screens ("impinged") for up to eight hours before being washed into a trough that empties into the discharge canal when the screens are rotated and cleaned. In the discharge canal, organisms that

were impinged are exposed to elevated temperatures, to high levels of oxidants, and possibly to physiologically stressful discharges from cooling tower holding ponds. Because there are no screens in front of the augmentation pump intake structures, benthic organisms of all sizes can be pumped through them. These organisms experience mechanical stresses as they contact the internal structures of the pumps and will be exposed to elevated temperatures and to potentially stressful chemical substances when they are emptied into the discharge canal.

Life stages of benthic organisms that pass through the 1-cm-mesh protective screens at the intake will circulate through the plant with the cooling water (i.e., be "entrained") and will experience thermal and mechanical stress (shear and pressure forces from pumps and high velocity flow through narrow condenser tubes). In addition, because chlorine is injected in the main cooling system during some seasons, entrained benthic organisms may be exposed to relatively high levels of oxidants that are produced during the decay of chlorine. The organisms continue to be exposed to the oxidants as they pass down the discharge canal during their two-hour transit to the receiving water body, where they are additionally stressed by elevated temperatures and by potentially stressful discharges from the cooling-tower holding ponds.

The thermal plume may contact benthic organisms in the estuary near the plant, possibly stressing them with elevated temperatures and other substances in power plant discharges (e.g., heavy metals, oxidants, organic material, and cooling tower residues).

D. LIFE HISTORY CHARACTERISTICS

Because most macrobenthic invertebrates live for only one or two years, they must continually replenish their populations through reproduction. Two

general reproductive modes occur: 1) gametes (eggs and sperm) or partially developed embryonic stages (referred to as larvae) are released into the water where planktonic development occurs, and 2) embryonic stages are retained by the adult and are protected as they grow -- a process referred to as brooding (Friedrich 1969; Thorson 1950; Grassle and Grassle 1974; Vance 1973). The microbenthos generally increase in number through cell division on the bottom, and the meiobenthos are mostly brooding organisms without planktonic stages.

Planktonic larvae are frequently more sensitive to fluctuations in environmental conditions than the adult organisms, and are therefore considered to be the critical stage in the life cycle of benthic organisms that produce them (Thorson 1950; Calabrese and Davis 1970). Planktonic larvae of benthic species could be entrained at Chalk Point, and the resulting entrainment process could culminate in their mortality, physiological impairment, or redistribution to areas that may be less favorable for growth and survival (Table 1). Larvae released in the discharge area would be subjected to physiological stresses associated with the thermal plume and other plant discharges (Table 1).

Juveniles of brooding species may be less stressed by plant operations than planktonic larvae because when the young of brooding species are released, they are completely developed and probably less likely to experience physiological and morphological impairment or mortality from entrainment. Also, because brooded young are not planktonic, they probably are less likely to be entrained than planktonic larvae.

Only limited information is available on the seasonal patterns of reproduction and the external factors controlling these patterns for macrobenthic invertebrates inhabiting the Chalk Point region of the Patuxent estuary. Most of this information is summarized in Appendix A. Based on these limited data,

it appears that some species reproduce during all seasons, and dominant macrobenthic species have major reproductive peaks in the warmer months (e.g., Pfitzenmeyer 1962; Shaw 1965; Orth 1971; Boesch 1973; Holland et al. 1979). Thus, larvae and mobile (juvenile to adult) life stages of some macrobenthic species could be subjected to entrainment stresses at Chalk Point during all seasons, but major entrainment effects would occur during warm months. There is little information available on the reproductive activity of meiobenthic and microbenthic organisms in the Patuxent estuary or the Chesapeake Bay. However, these organisms are only occasionally in the water column (when sediments are disturbed) so their chances of being entrained are low.

Juvenile and adult benthos can be divided into two broad categories based on whether they live on or in the bottom: the epifauna and the infauna, respectively (Petersen 1913). Epifaunal organisms move about on the estuarine floor (e.g., crabs, shrimp, and snails) or are sessile and live firmly attached to hard objects slightly off the bottom (e.g., oysters and mussels). During all seasons, near-plant mobile epifauna smaller than 1 cm could be entrained into the power plant with intake flows. During warm months, epifaunal benthic organisms of all sizes could be entrained into augmentation pumps. Nearplant mobile epifauna larger than 1 cm (e.g., blue crabs) could be impinged on the traveling screens, or be entrained into augmentation pumps (Table 1).

Benthic organisms, particularly the infauna, inhabiting the discharge canal and immediate discharge region would be exposed to higher than ambient temperatures, relatively high concentrations of oxidants, and possibly, excess organic enrichment. The area of the estuary affected by plant operations would depend on many factors (e.g., size of the thermal plume and the ratio between river flow and the plant intake/discharge flows). Elevated temperatures

in the discharge region could affect the rate or timing of reproduction of benthic organisms there, especially meiobenthos and microbenthos, which have very short generation times.

The remains of phytoplankton and zooplankton killed by entrainment settle to the bottom in the discharge canal and nearfield region where they enrich sediments with organic material. The microbenthos could rapidly colonize this organic material as it settles to the bottom. Once on the bottom, bacteria-eating meiobenthic and deposit-feeding macrobenthic organisms could feed on the decaying organic material and its microbenthic colonizers. Organic enrichment from power plant operation could increase meiobenthic and macrobenthic population sizes and productivity in the discharge area. Filter-feeding benthic organisms, particularly sessile epifauna, could also feed on entrainment-produced suspended organic material (i.e., in the immediate discharge waters). Theoretically, their populations could also increase in size and/or productivity near the discharge site as long as natural sedimentation rates and turbidity in the Patuxent were not great enough to smother them. Newly settled benthic larvae are especially vulnerable to being smothered by sediments.

The condenser tubes of the Chalk Point plant are made of a copper-nickel alloy that is corrosion-resistant but not inert. It has been estimated that in saline waters, copper-nickel condenser tubes will corrode at the average rate of 0.008 mm per year and the maximum rate of 0.03 mm per year (Tomashov 1966). Copper released from estuarine power plants is adsorbed on particles suspended in the cooling water. These copper-enriched particles ultimately settle to the bottom, raising the copper level in local sediments. Benthic organisms such as oysters could ingest some of these particles as they settle to the bottom, or deposit feeders such as clams could ingest them after they

settle to the bottom. There is strong evidence from previous studies conducted near the Chalk Point site that the sediments, water, and oysters are or have been enriched by copper released from power plant operations (e.g., Roosenburg 1969; Eaton and Chamberlin 1979).

IV. STUDY METHODS

The Patuxent benthic program consisted of several interconnected field projects:

- Comprehensive estuarine-wide surveys that sampled the microbenthos, meiobenthos, macrobenthos, and physical/chemical factors to determine the effects of plant operations on their estuarine-wide distributional patterns.
- Nearfield surveys that sampled the macrobenthos and physical/chemical factors near the Chalk Point SES to determine if distributional patterns and plant effects observed during the estuarine-wide surveys were maintained in the nearfield region over an annual cycle. The nearfield surveys also provided baseline information on the pattern and magnitude of seasonal variation in benthic population and community characteristics and physical/chemical factors.
- A study of the population characteristics of Macoma balthica throughout the estuary and in the nearfield region, including a comparison of reference and discharge areas during the preoperational and operational periods to determine the effects of plant operations on the population dynamics of this clam.
- Predator exclusion experiments, which sampled the macrobenthos and physical/chemical factors at sites where predators had been excluded, to determine the role of predators in controlling macrobenthic standing stocks.
- Surveys of the macrobenthos and physical/chemical factors in the discharge canal to determine the effects of plant operations on benthic organisms inhabiting the canal.
- Recolonization experiments in the discharge canal and the adjacent estuary using discharge canal and natural estuarine sediments to determine if discharge canal sediments or other environmental conditions in the discharge canal were the major factor controlling benthic standing stock sizes in the canal.
- Organic enrichment experiments to determine the response pattern of macrobenthic organisms inhabiting the Patuxent estuary to artificially introduced increases in the levels of organic matter settling to the bottom.

Table 2 summarizes sampling information (e.g., parameters measured, sampling methods, sampling frequency, and stations sampled) for the various field

projects conducted during the Patuxent benthic program. Station locations are shown in Figures 1 and 3.

A. FIELD METHODS

The size, shape, and depth of the thermal plume varied seasonally with tidal stage, meteorological conditions (e.g., wind direction, duration, and velocity), and plant load. Details of the dimensions of the thermal plume are discussed by Lacy and Krueger (1978a, 1978b, 1979), by Binkerd et al. (1980), and later in this report. However, the following description of spatial distribution of excess temperatures when the total plant operating capacity per unit was about 250 MWe is relevant to the location of benthic sampling stations. Stations 1 through 4 were downstream of any measurable thermal effects from power plant operations. Stations 5, 6, 42, and 26 infrequently experienced about 0.5°C excess temperatures on some ebbing tides, but were probably out of range of any major plant effects. Stations 41 and 25 were exposed to excess temperatures of 1° to 2°C during ebbing tides and were indicators of downstream farfield effects (Figure 3). Stations 7, 8, and 43 were frequently exposed to excess temperatures of 2° to 4°C and were indicators of nearfield effects (Figure 3). Stations 9 and 27 were exposed to excess temperatures of 1° to 2°C during flooding tides and were indicators of upstream farfield effects (Figure 3). Stations 28 and 10 infrequently experienced excess temperatures of about 0.5°C on some flooding tides, but were probably out of range of any major plant effects. Stations 11, 12, and 22 were upstream of any measurable thermal effects from plant operations. Stations 13 through 16 were in the discharge canal.

1. Macrobenthic Sampling Program

Two comprehensive estuarine-wide surveys of the macrobenthic community and Macoma balthica population characteristics were conducted during periods of high flow (April 1978 and September 1979). One estuarine-wide survey was conducted during a period of low flow (October 1978). Stations 1 through 12 were sampled in the 1978 through 1979 studies, and stations 1 through 12, 22, 25 through 28, and 41 through 43 were sampled in the September 1979 study. All stations except 42 and 43 were along the 3-m depth contour and were chosen to have substrate characteristics that were as similar as possible. Stations 42 and 43 were channel stations along the 4- to 5-m depth contour.

Macrobenthic community and Macoma balthica population characteristics were monitored monthly in the nearfield region between April 1978 and May 1979, and bimonthly between July 1979 and May 1980. Stations 5, 6, 7, and 8 were sampled during the 1978 through 1979 nearfield studies, and stations 3, 5, 41, 8, 9, and 10 were sampled in the 1979 through 1980 nearfield studies. Three discharge canal stations (stations 13, 14, and 15) were sampled from July 1978 through May 1979. A remaining discharge canal station (station 16) was sampled only once during July 1978 because sediments there were mostly shell and not comparable to those at the other discharge canal stations.

A hydraulic grab (0.12 m^2) was used to collect macrobenthic samples between April 1978 and May 1979. To process the larger number of samples taken between July 1979 and May 1980 without a significant increase in labor, samples were collected with a hand-operated box corer, which collected smaller volumes of sediment than the hydraulic grab. The box corer (0.02 m^2) was selected because it sampled at approximately the same depth as the hydraulic

grab (≈ 25 cm) but only sampled about 17% of the area (200 cm^2 vs $1,200\text{ cm}^2$). This reduction in the size of the area sampled did not significantly reduce the information on the standing stock size of numerically important species. The hydraulic grab was used again to sample channel stations 42 and 43 in September 1979.

Four replicate samples were collected at the monthly or bimonthly near-field stations, and three replicates were collected at the remaining stations. All macrobenthic samples were sieved in the field through a 0.5-mm screen. Material retained on the screen was preserved in a 10% buffered formalin-rose bengal solution and transported to the laboratory where organisms were identified and counted. Each Macoma balthica collected in the samples was measured for shell length, and by using size distributions and the growth rings on a number of shells, M. balthica ages were determined for various size ranges.

2. Meiobenthic and Microbenthic Sampling Programs

Two comprehensive surveys of meiobenthic community characteristics were conducted -- one during a warm, low-flow period (July 1979) and one during a cold, high-flow period (January 1980). During these surveys, three replicate, 10-cm^2 hand cores were collected from box-core samples at stations 3, 5, 41, 8, 9, and 10 (Figures 1 and 3). The 10-cm^2 cores were collected after the box-core samples had been carefully extracted into a dishpan. Meiobenthos were also sampled to estimate standing stock size during July 1979 in Osborn Cove, a protected location on St. Leonard's Creek, a tributary of the lower Patuxent. Each meiobenthic sample (an entire 10-cm^2 core) was fixed in the field in a 10% formalin-rose bengal solution and transported to the laboratory

where all organisms retained on a 63- μ m screen were identified and counted. Meiobenthic organisms were separated from detritus and coarse sediments by first using a decanting procedure and then standard floatation techniques. It was impractical to identify meiobenthic organisms to the species level, so they were only identified to the major taxa level (e.g., nematodes, harpacticoid copepods, and oligochaetes).

A single comprehensive microbenthic survey conducted in July 1979 estimated microbenthic standing stock size by measuring ATP levels in sediments. ATP samples were collected from stations 3, 5, 41, 8, 9, and 10. At approximately the same time, ATP levels were also estimated in a sand, a muddy-sand, and a mud habitat of Osborn Cove. All microbenthic samples were approximately 1-cm² subsamples of extracted box-core samples. Details of ATP sampling and extraction procedures are presented in Mountford (1979) and will not be reviewed here.

3. Physical/Chemical Sampling Programs

Point measurements of temperature, salinity, and dissolved oxygen were made at 1-m depth intervals in the water column over each station when each biological sample was collected. PEPCO's semiannual progress reports to WRA and other PPSP sponsored field studies provided additional physical/chemical data.

In April 1978, sediment samples were taken from three depths at all stations: 1) surface; 2) 10 to 15 cm below the sediment surface; and 3) 25 to 30 cm below the sediment surface. Because physical characteristics of the sediments in these samples did not vary significantly with depth, only surface sediment samples were collected with subsequent benthic samples.

Sediment samples were frozen until they were processed in the laboratory. Laboratory processing determined interstitial salinity, water content, mechanical properties, and organic carbon content of the samples by standard procedures (Buchanan and Kain 1971).

4. Special Studies

a. Predator Exclusion Experiments

Two cages (each 1.9 m long, 1.9 m wide, 2.6 m high) constructed of angle iron and covered with 12-mm-mesh, galvanized hardware cloth, were placed over the bottom at a depth of 1 m during April 1978. One cage was located near station 5, about 5 km downstream of the discharge canal terminus, and the other near station 7, about 0.5 km downstream of the terminus (Figure 3). Cages were sampled by removing the top and taking seven box cores (0.02-m^2 each) from inside the cage. The top panel was then replaced and marked to indicate the general area inside the cage that had been sampled. Box cores were taken from a different area inside the cage during each sampling period, and only 20% of the area inside each cage was sampled during the experiment. Seven reference box cores (0.02-m^2 each) were taken randomly in a circular pattern around the outside of each cage during each sampling period. The same reference areas probably were not sampled twice since the diameter of the circular sampling pattern used was varied on each sampling date. One core from inside the cages and one reference core were used for sediment samples and were processed in the same manner as other sediment samples as described above. The remaining box cores were processed in the same manner as other macrobenthic samples. Cages were sampled monthly from April through August 1978.

B. ANALYSIS METHODS

1. General Analysis Methods

Standard statistical procedures available on the University of Maryland's Biomedical Computer Programs (BMD) and the applied statistical package of the Texas Instruments Model 59, desk-top calculator were used to compute means, standard deviations, and variances; to calculate correlation coefficients and partial correlation coefficients among variables; to display data; and to conduct routine analysis of variance (ANOVA) and analysis of covariance (ACOVA). Additional details of these routine analyses are discussed at appropriate places in the text.

2. Analysis Scheme Applied to Regional Surveys

To describe and model the relationship between benthic standing stock size and the measured physical/chemical factors, we used BMD program number BMDP2R (Dixon 1975) to compute multiple linear regression equations in a step-wise manner. At each step, the physical/chemical factor that 1) made the greatest reduction in the error sums of squares, 2) had the highest partial correlation with the dependent variable (partial correlations were computed on the variables that had already been included in the equation), and 3) had the highest F-value was added to the regression equation. Variables were not added or were removed from the regression equation when F-values were not significant at the 0.05 probability level. The raw data counts of standing stock used in these analyses were transformed by the function:

$$Y = \ln (\text{raw data count} + 1)$$

This function was selected because it homogenized the variance for the majority of the species, and it was desirable to use the same transformation in as many cases as possible. Square root transformations were tried in about 25% of the analyses, and the results were not significantly different from those of logarithmically transformed data. If they were proportional, raw physical/chemical data were transformed by the function:

$$Y = \arcsin \sqrt{\text{proportion}} .$$

Analyses were also performed using untransformed physical/chemical data. The transformation of proportional data using the arcsin-square-root transformation did not alter the analytical results in any case. For this reason, only the results of analyses using untransformed physical/chemical data are presented in the text.

To derive the regression equations needed to predict standing stock sizes in the discharge area, only data from reference stations were used. Data from stations frequently exposed to temperatures 2.0°C or more above ambient were excluded from the analyses (i.e., stations 7, 8, 9, 25, 26, 27, 28, 41, and 43, shown in Figure 3). However, predicted and observed values were compared for all stations (particularly affected locations) as one means of determining the magnitude of power plant effects.

3. Analysis of Growth and Mortality Data

The relationship between age and length of Macoma balthica was determined using the Brody-von Bertalanffy equation by plotting the mean length at age t against the mean length at age $t + 1$. The parameters of the Brody-von Bertalanffy curve, $L = L_{\infty} [1 - e^{-k(t - t_0)}]$, can be estimated from

the slope and intercept of Ford-Walford plots (Crisp 1971). The slope (m) of a Ford Walford plot is related to the growth rate (k) as $m = e^{-k}$, and asymptotic length (L_{∞}) can be estimated from the intercept (b) as $L_{\infty} = \frac{b}{1-m}$. Clearly, this equation does not adequately estimate the size or length at zero age for M. balthica. However, it does estimate size at the time this organism settles to the bottom (≈ 0.5 mm).

The model for the determination of size-specific mortality rates deals directly with the dynamics of size distributions. A detailed description of the relationship between size data and mortality rates is given in Ebert (1973). The approach used here drew from this earlier work by using a conservation equation for population density (Van Sickle 1977) with size-specific, rather than age-specific, mortality and growth rates as the parameters. When the model is applied to populations that are assumed to have fixed annual age and size distributions, it yields a formula for an instantaneous mortality rate as a function of individual growth rate and the shape of the size distribution.

Mortalities can then be estimated directly from observed size-frequency curves and growth data, without explicitly determining the population's age distribution.

Given the assumptions that growth and mortality rates are size-specific functions, the dynamics of the population density function $N(z,t)$, where $\int_{z_2}^{z_1} N(z,t) dz$ is the total number of individuals in the size interval (z_1, z_2) at time t , are described by the following conservation equation for the flow of organisms through a size distribution:

$$\frac{\delta N(z,t)}{\delta t} + \frac{\delta}{\delta z} [g(z)N(z,t)] = -\mu(z)N(z,t). \quad (1)$$

The complete derivation of this equation is discussed by Sinko and Streifer (1967). The conservation equation may be roughly interpreted as follows:

$\frac{\delta N(z,t)}{\delta t}$ represents the net rate of change in numbers of individuals in a thin size interval $(z, z + dz)$. This term is actually the sum of two terms. The first is the net loss rate of individuals through a size interval $(z, z + dz)$ due to growth $\left(\frac{-\delta}{\delta z} \left[g(z)N(z,t) \right] \right)$ and the second term is the loss rate due to mortality $[-\mu(z)N(z,t)]$. A complete description of a self-sustaining population requires only a size distribution at time $t = 0$ and an arbitrary recruitment function, $R(t)$, the rate of appearance of new individuals of size z_R (smallest size observed in population).

This model takes a simple form when $N(z,t)$ is the size distribution of a stationary population (i.e., where $R(t)$ is constant and equal to the population death rate). Then the stationary size distribution, $N_s(z)$, becomes:

$$\frac{d}{dz} \left[\ln N_s(z) \right] = - \left[\frac{\mu(z) + g'(z)}{g(z)} \right] \quad (2)$$

where $g'(z) = \frac{dg(z)}{dz}$.

This equation serves as a basis for estimating mortality rates in steady-state populations whenever growth and size-frequency data are available. The equation can be solved for $\mu(z)$ as:

$$\mu(z) = -g(z) \frac{d}{dz} \left[\ln N_s(z) \right] - g'(z). \quad (3)$$

When comprehensive growth and size-frequency data are available, mortality can be estimated from this equation on a size-specific basis. First, the full size spectrum of the population is divided into j size classes. Then,

mortality within a size class, j , is assumed to be the same for all members of that size class. If j stands for the size interval $(z_j, z_j + 1)$, and if the growth rates $g(z_j)$, $N_z(z_j + 1)$, and N_j^* , and the total number or proportion of organisms in class j are known, then μ_j is computed as:

$$\mu_j = \frac{1}{N_j^*} \left[g(z_j) N_s(z_j) - g(z_j + 1) N_z(z_j + 1) \right] \quad (4)$$

which is obtained by integrating equation (2) from z_j to $z_j + 1$ (Van Sickle 1977). This equation is not a unique discrete approximation of the continuous distribution but does have the advantage of not containing the derivatives and logarithms seen in the continuous equations (i.e., the original data are easier to use).

4. Analysis Schemes Applied to Other Field Experiments

Univariate and multivariate analyses of variance (ANOVA and MANOVA) were conducted to determine if sampling month, location where experiments were conducted, source of sediment, artificially introduced organic material, and/or exclusion of predators had significant effects on macrobenthic and meiobenthic assemblages during the recolonization of "azoic" sediments, during organic enrichment experiments, and during predator exclusion experiments.

Raw standing stock macrobenthic and meiobenthic counts were transformed by the functions (Dixon 1975):

$$Y = \sqrt{\text{raw data count}} + \sqrt{\text{raw data count} + 1}$$

and

$$Y = \ln (\text{raw data count} + 1).$$

Bartlett's tests were performed on the cell distributions of the transformed and nontransformed counts (Sokal and Rohlf 1969) to determine which transformations best met the assumptions of ANOVA (i.e., normality and homogeneity of variance). Taxa with counts that had no significant variance in the heterogeneity of error ($\alpha = 0.05$) were tested for experimental effects using univariate parametric ANOVA's. Taxa whose distributions could not be suitably transformed for parametric analyses were tested for experimental effects by using a univariate nonparametric ANOVA (Wilson 1956).

Multivariate analyses of variance (MANOVA) were conducted on subsets of observation vectors for linearly-independent taxa chosen from those taxa used in the univariate parametric analyses of variance. Taxa in the subsets were chosen using a stepwise discriminant procedure (BMDP7M, see Dixon 1975). The discriminant program entered variables that maximized the among-cell separation and excluded only variables that had observation vectors that were linear combinations of variables previously entered (i.e., the multiple correlation coefficient exceeded a specified tolerance level). The elimination of linearly dependent observation vectors guarded against singularities in the error matrix during the MANOVA procedure. By setting the F to enter and/or remove artificially low values, all independent taxa contributing to among-cell separation were entered into the analysis. These taxa were then used in the general linear MANOVA models (SAS 1979) that tested for experimental effects. At the present time, little is known about the comparative power differences for various MANOVA test statistics. For this reason, the three most commonly used ones were included in our MANOVA results (i.e., Hotelling-Lawley trace, Pillai's trace, and Wilks' criterion).

V. RESULTS

A. SUMMARY OF PHYSICAL/CHEMICAL DATA FROM FIELD SURVEYS

1. Salinity

Salinity data collected in comprehensive benthic surveys during 1978 through 1980 are presented in Appendix B. Water column salinities ranged from less than 1 ppt at station 12 to 7.5 ppt at station 1 in the April 1978 survey (Figure 4); from about 2 ppt at station 12 to 15 ppt at station 1 in the October 1978 survey (Figure 5); and less than 0.5 ppt at sample sites upstream of Station 10 to 11.0 ppt at Station 1 in the September 1979 survey (Figure 6). Interstitial salinities (of water between sediment particles) were generally similar to water column salinities during all the comprehensive surveys. Salinities at the plant site ranged between oligohaline (0.5 to 5 ppt) and mesohaline (5 to 18 ppt) during the spring when freshwater flows were high (Figures 7 through 16) and decreased or increased up- and downstream from there at the rate of about 0.5 ppt per km (Lacy and Krueger 1978a, 1978b, 1979). During summer and fall when freshwater flows were generally low, salinities at the plant site were mesohaline (Figures 7 through 16) and changed up- and downstream from there at the rate of about 1 ppt per km of estuary (Lacy and Krueger 1978a, 1978b, 1979). During low flow conditions, the oligohaline-mesohaline transition zone was upstream of the plant near stations 11 and 12 (Figure 4).

A notable deviation from the general trend described above occurred during summer and fall of 1979 when salinities throughout the Patuxent were below the general fall ranges (Figures 6, 7, 9, 11, 14, 15, and 16) as a result of the unusually large rainfall in August and September (Table 3).

Because plant intake structures are 2.5 km downstream of the discharge canal terminus, plant discharges theoretically should be slightly saltier than the Patuxent estuary waters into which they are released. However, such differences were not generally measured during this study or by other PPSP studies conducted in 1978 through 1980. Most of the time, salinities in the discharge area were 1 to 3 ppt lower than they were at the intake area. These data are in close agreement with the 1.5 ppt mean lower salinity differential between intake and discharge water reported by other studies (e.g., Carter 1968; Binkerd et al. 1980) and apparently reflect mixing processes in the discharge canal and in Swanson Creek.

The salinity differential between sampling sites in the discharge area and downstream reference areas was frequently over a range (between 3 to 7 ppt) that could affect the distributional pattern of benthic organisms. Because this salinity differential is at a relatively critical range for physiological processes, benthic population and community characteristics at sampling stations near the discharge site (e.g., stations 41, 7, 8, and 9) would be expected a priori to be different from those at downstream or upstream reference locations. However, we could use salinity data collected in the comprehensive estuarine-wide survey (which included a number of stations both upstream and downstream of the discharge area) during low flow and high flow conditions to adjust our findings on benthic population and community characteristics for natural variations due to salinity and other environmental factors that vary with salinity. These adjustments were necessary prior to assessing plant effects.

2. Temperature

Temperature data collected during the 1978 through 1980 benthic studies (presented in Appendix B) provide information on seasonal temperature trends for the Patuxent estuary during the study period but do not indicate the size of the thermally-affected region.

In the fall and spring, the Chesapeake Bay and the relatively deep mesohaline portions of the Patuxent responded to air temperatures at a slower rate than the relatively shallow oligohaline and tidal freshwater regions of the upper Patuxent. As a result, water temperatures decreased from station 12 to station 1 in the fall and increased from station 12 to station 1 in the spring. The Patuxent main stem had only a small longitudinal gradient in water temperature during winter or summer.

Hydrothermal studies (Lacy and Krueger 1978a, 1978b, 1979; Binkerd et al. 1980) conducted when the plant was operating at about 250 MWe per unit (or 50% allowable capacity) indicated that on flooding tides, excess temperatures of 1°C sometimes occurred as far upstream as Deep Landing (approximately 6 km above the point of discharge, between stations 10 and 11) and, on ebbing tides, 1°C excess temperatures occurred as far downstream as Benedict (approximately 6 km below the point of discharge, near station 4). Waters 2°C above ambient occurred as far downstream as Chalk Point (approximately 2 km downstream of the discharge site) and as far upstream as Trueman Point (approximately 2 km upstream of the discharge site). The area of bottom covered by measurable excess temperatures of 1°C was generally confined to a region approximately 1 km above or below the discharge canal terminus between stations 9 and 41. The area of bottom touched by waters heated 2°C or more above ambient (averaged over a tidal cycle) was about 275 hectares (Holland 1980).

Marked lateral differences in excess temperatures occurred on ebbing tides, with the downstream extent being greatest on the western shore between Chalk Point and the discharge canal terminus (Figure 3). On flooding tides, measurable excess temperatures were transported upstream along the center of the estuary as well as along the western shore, especially between the discharge canal terminus and Eagle Harbor (Figure 3). The size of the thermally affected region varied with meteorological conditions. During low flow conditions, cooling water recirculation was as high as 30% (Binkerd et al. 1980). Although the extent of the thermal plume in shallow areas was not completely evaluated, it appears that shallow-water habitats between stations 41 and 9 were probably exposed to excess temperatures between 0.5 and 2.0°C, depending on location, tides, and meteorological conditions (Binkerd et al. 1980).

In summary, the discharge of heated water by the Chalk Point SES influenced a large region of the Patuxent estuary (approximately 10 to 12 km in length). Furthermore, because the discharge water is slightly more saline than ambient Patuxent water at the point of release, the thermal plume frequently sinks. Shallow habitats (i.e., less than 2- to 3-m in depth) along the western shore between Chalk Point and Trueman Point (between stations 41 and 9) are probably exposed to relatively high excess temperatures.

3. Dissolved Oxygen

Freshwater flow (with its influence on salinity) and seasonal changes in temperature (with the associated changes in production and respiration) are the major factors controlling dissolved oxygen levels in the Patuxent (Mihursky and Boynton 1979). Dissolved oxygen data collected by benthic studies are

summarized in Appendix B. During winter and spring, bottom waters were generally saturated with dissolved oxygen (10 to 12 mg/liter). Frequently during summer and fall, dissolved oxygen values upstream of station 5 were only 75% of saturation (4 to 7 mg/liter). Even though the amount of the decrease in dissolved oxygen that can be attributed to longitudinal variation in salinity and temperature was not determined, it is not likely that adjustments for salinity and temperature would explain a significant portion of the observed variation in dissolved oxygen levels.

The general decrease in summer dissolved oxygen levels between Lower Marlboro and Benedict since the early 1960's is probably related to urban development in the upper Patuxent watershed (Mihursky and Boynton 1979). Thus, the below-saturation levels observed near the plant site and in areas upstream were probably not related to power plant operations. Dissolved oxygen values were never low enough in the estuary or near the plant site to impact benthic organisms (< 2 ppm).

4. Depth and Substrate Characteristics

The depths of all sampling locations were approximately 3 m except for the 4- to 5-m channel stations (stations 42 and 43) sampled during the September 1979 comprehensive survey. The physical characteristics of the sediments at the macrobenthic community sample sites are summarized in Figures 4 through 16 and in Appendix B. A natural longitudinal gradient in the sand content of sediments along the 3-m depth contour made it difficult to consistently locate sample sites along this contour so that sediment at sites downstream from Benedict (station 4) would have a similar silt-clay content to sites upstream from Benedict. Sediments at station 2 contained particularly low silt-clay

values (Figures 4 through 6). The silt-clay as well as organic content of sediments obtained in April and October 1978 at station 4 were slightly higher than would be expected in this region of the Patuxent, possibly because the station is near the mouth of Indian Creek. Therefore, we relocated station 4 during the September 1979 comprehensive survey to the eastern shore of the Patuxent opposite its confluence with Indian Creek. This station had sediments with a lower organic content and a lower silt-clay content, which were more in line with what we expected for the area. Despite the wide range of substrate types in the Patuxent, sediments at all benthic sample sites, except possibly those at stations 1 through 3, were relatively similar (e.g., similarity in silt-clay and organic content of sediments among stations).

Sediment characteristics showed little temporal variation associated with seasonal changes in biological and physical processes such as primary productivity, detrital flux, secondary productivity, sediment reworking by deposit-feeding invertebrates, and river flow. Total combustible carbon in surface sediments appeared to increase slightly from summer through fall at some stations (Figures 4 through 16).

Large station-to-station differences in community characteristics were, thus, not likely attributable to station-to-station differences in sediment characteristics. Although there may have been some minor station-to-station variation in community characteristics due to sediment properties, community data could be adjusted for this variability using the analytical techniques described in the methods section.

5. Relationships Among Physical/Chemical Factors

Relationships among the physical/chemical factors during the comprehensive survey conducted in September 1979 are summarized in Table 4. This analysis indicates a significant correlation between salinity and the silt-clay content of sediments. Sediments with highest silt-clay values were consistently in areas with lower salinities during all sampling periods. In addition, all sediment characteristics were interrelated: sediments with the highest silt-clay values generally had the highest moisture content, the highest total carbon content, and the highest available carbon content. These relationships were also evident during all the other sampling periods. The influence of salinity on sediment characteristics appeared to be related to the location of the turbidity maximum in the estuary and the effect of salinity on sedimentation rates and processes. For a detailed discussion of the influence of salinity on sedimentation processes, refer to Lippson et al. (1979).

Dissolved oxygen and temperature data were also significantly correlated with each other in the September 1979 data set because of the similar longitudinal trends observed for these variables (Table 4). During spring, this pattern reversed, and during winter and summer, the two variables were not related (Lacy and Krueger 1978a, 1978b, 1979; Binkerd et al. 1980).

Total carbon content and the available carbon content of sediments, both of which could influence dissolved oxygen levels in the water column (i.e., oxygen demand created as organic materials decompose), were significantly correlated with water-column dissolved oxygen for most surveys (Table 4). Thus, some of the longitudinal variation in dissolved oxygen levels could be due to upstream-downstream differences in oxygen demand of sediments

resulting from the carbon content of sediments. The source of carbon in bottom sediments of the Patuxent is probably detritus from upstream marshes as well as phytoplankton detritus resulting from upstream nutrient and organic inputs.

B. SUMMARY OF BIOLOGICAL DATA FROM FIELD SURVEYS

The April 1978 through May 1980 macrobenthic and meiobenthic data are summarized in Appendix B.

Salinity is generally considered to be the major environmental factor controlling the distribution of benthic invertebrates along the length of estuaries (e.g., Carriker 1967; Boesch 1977), and benthic populations are generally distributed along estuarine salinity gradients in several characteristic patterns that are related to the physiological tolerances of component species to salinity. Thus, assemblages of benthic organisms that are physiologically adapted to and characteristic of relatively broad estuarine salinity zones have been identified (e.g., Boesch 1977). Because the species composing the various assemblages frequently have similar biological characteristics, benthic ecologists have also been able to determine adaptive strategies and other biological characteristics favored by organisms within particular salinity zones (e.g., Carriker 1967; Boesch 1977).

The portion of the Patuxent estuary in which benthic surveys were conducted included three of the major salinity zones of the Venice estuarine classification scheme: the tidal freshwater zone (0 to 0.5 ppt), the oligohaline zone (0.5 to 5 ppt), and the mesohaline zone (5 to 18 ppt). Studies of the riverine portion of the Patuxent were not part of the PPSP-sponsored Patuxent benthic studies. A polyhaline zone (18 to 30 ppt) was not sampled because

it is generally not in the Patuxent, and only occurs near the mouth of the estuary during years of extremely low runoff.

1. Regional Surveys

a. Species Composition and Diversity of Macrobenthos

Forty-six species of infaunal macrobenthic species were collected during this study. Appendix A lists these species plus species collected in other Patuxent benthic surveys, their reported distributional ranges along the estuarine gradient, feeding mode, reproductive mode, and season of reproduction in the Chesapeake Bay and in other temperate zone estuaries. The data in Appendix A compare favorably with macrobenthic data collected from similar habitats in other Chesapeake Bay tributaries (Pfitzenmeyer 1970, 1973; Boesch 1973, 1974, 1977; deFur 1973; Ecological Analysts, Inc. 1974; Polgar et al. 1975; Boesch et al. 1976; Haire 1978; Lippson et al. 1979).

Macrobenthic communities inhabiting the Patuxent were composed of three major types of species based on salinity tolerances: 1) eurytolerant marine species, 2) estuarine species, and 3) freshwater species (Figure 17, inset a). Only a few eurytolerant marine, macrobenthic species can tolerate salinities lower than 25 ppt. These species can live in mesohaline and oligohaline waters and are found as far upstream in the Chesapeake Bay as the Patuxent. Members of this group that were frequently collected during our study were Eteone heteropoda, Glycinde solitaria, Heteromastus filiformis, Macoma phenax, Mya arenaria, Nereis succinea, and Streblospio benedicti. Eurytolerant marine macrobenthic organisms, especially those commonly found in the Patuxent, are rarely abundant in polyhaline habitats of the lower Bay (Boesch 1977), even

though they are physiologically adapted to these higher salinity environments. Apparently, they are excluded from higher salinity habitats by biological interactions such as competition and attain their maximum abundances in mesohaline habitats near the lower limits of their salinity tolerances (Boesch 1977).

The true estuarine species generally have maximum densities in the middle reaches of the Chesapeake Bay and its tributaries where salinities are between 2 and 10 ppt (Boesch 1977; Lippson et al. 1979). Estuarine species inhabiting the Patuxent were Cyathura polita, Leptocheirus plumulosus, Macoma balthica, Monoculodes edwardsi, Rangia cuneata, Tubificodes heterochaetus, and Scolecoides viridis. Although these organisms are physiologically capable of tolerating higher salinities, most of them rarely obtain high abundances in habitats where annual mean salinities are above 15 to 18 ppt. Some are restricted to the lower-salinity, middle reaches of estuaries by behavioral and physiological adaptations, particularly adaptations associated with reproduction. For example, Cain (1975) found that a change in salinity, up from 0 ppt or down from 10 to 15 ppt, was required to induce spawning in the brackish-water clam, R. cuneata. In addition, larval stages of R. cuneata developed successfully only at salinities between 2 and 10 ppt. However, estuarine species may be excluded or limited in abundance in high salinity habitats by competitive interactions or by predation pressures from bottom feeding fish (Boesch 1977).

Freshwater species generally attain density and diversity maxima in the riverine portions of estuaries, as they do in the headwaters of the Patuxent and other Chesapeake Bay tributaries. Intolerance to salt water limits their downstream distribution. Because this program only sampled tidal-freshwater

habitats, which are marginal environments for most freshwater organisms, relatively few freshwater species were collected. The most frequently collected ones were an unidentified Gammarus sp., Limnodrilus hoffmeisteri, and Tendipedidae larvae. If sampling had been conducted farther upstream into "true" riverine habitats, more freshwater species would have been collected.

Figures 17 through 19 summarize the change in the number of species along the Patuxent salinity gradient during the comprehensive estuary-wide surveys. The approximate range in the number of species reported along the salinity gradient of other tributaries of the Chesapeake Bay is shown in Figure 17b. The number of species from the various salinity zones of the Patuxent generally corresponded to these ranges. However, as is apparent in Figures 17 through 19, the spatial distributions of species fluctuated with freshwater flows (i.e., April 1978 and September 1979 were high flow/low salinity periods, and October 1978 was a low flow/high salinity period).

Table 5 summarizes the data on macrobenthic species diversity from the Patuxent for high and low flow conditions. Although diversity indices are not particularly sensitive indicators of the effects of pollution on macrobenthic communities (e.g., Gray 1971; Polgar et al. 1975), they are a convenient means of characterizing temporal and spatial trends in the state of a community. During the high flow periods in April 1978 and September 1979, there was a marked decline in the number of species and the species richness (H'_{\max}) of the benthic community in the oligohaline zone just upstream of the plant site (stations 10 through 12; see Figures 17 and 19, Table 5). During low flow conditions (October 1978), when salinities were mesohaline up to Jones Point (20 km above the plant site), a decline in the number of benthic species and species richness of the benthic community was not observed in the portions of

the Patuxent sampled (Figure 18; Table 5). Tidal freshwater habitats were not sampled during surveys in the low-flow period because they occurred farther upstream than the area sampled by our program.

Although the number of species and species richness of macrobenthic samples are not sensitive indicators of benthic community complexity, they are community characteristics that vary in a predictable manner with salinity and point-source perturbations. There was no indication from the diversity data that power-plant operations at Chalk Point affected these two community characteristics (Figures 17 through 19; Table 5). However, the discharge region showed a marked change in the distribution of the individuals among the component species, i.e., in community structure (see stations 7, 8, and 9 in Table 5). As a result, diversity measures of the evenness (J and E) of the distribution of individuals among the species and overall diversity (H') of the benthic fauna were lower in the immediate discharge region than at upstream or downstream reference locations (Table 5). As will be discussed in detail later, the change in community structure in the immediate discharge region was the result of higher than "normal" abundances of a few species (mostly deposit feeding oligochaetes) at the discharge site (i.e., species equitability changed).

Except in the immediate discharge area, the species composition and diversity patterns of Patuxent macrobenthic communities were similar to those reported for other Chesapeake Bay tributaries and do not indicate that macrobenthic communities in the Patuxent were responding to organic and nutrient inputs from upstream sources (e.g., Pfitzenmeyer 1970, 1973; Boesch 1974; Boesch et al. 1976; Mountford et al. 1977). However, it should be kept in mind that our sampling did not extend upstream of Western Branch.

b. Macrobenthic Distribution

Figures 20 through 25 summarize the spatial distribution of density (number of individuals per m^2) and biomass (g ash-free dry weight per m^2) of macrobenthic organisms during the three comprehensive estuarine-wide surveys. Macrobenthic density during all surveys was maximum or near maximum in the immediate discharge region (Figures 20 through 22). This pattern was not affected by seasonal and year-to-year variations in freshwater flows. The species making the major contribution to the numbers of individuals was the oligochaete, Tubificodes heterochaetus. In the discharge region this species accounted for about 80 to 90% of the total number of individuals, but at other stations, only accounted for between 5 and 20% (Figures 20 through 22). Oligochaete densities were also higher in the thermally affected regions during the benthic surveys conducted by ANSP in 1978 and 1979 (Krueger 1978a, 1978b, 1979) and during all of our monthly near-plant surveys (see data summaries, Appendix B).

Densities of Tubificodes heterochaetus are generally maximum in oligohaline regions of the Chesapeake Bay and other temperate zone, western Atlantic estuaries (e.g., Diaz 1980; Crumb 1977; Tenore 1972; deFur 1973; Boesch 1973, 1974, 1977; Ecological Analysts, Inc. 1974; Polgar et al. 1975; Redding and Cory 1975; Boesch et al. 1976; Calder et al. 1977; Haire 1978; Lippson et al. 1979). However, densities of T. heterochaetus were 4 to 10 times higher in the Chalk Point discharge area than reported for similar habitats elsewhere. Furthermore, in the Chalk Point discharge region, the density of T. heterochaetus varied over a much smaller spatial scale than could be explained by spatial variation in salinity. When densities of T. heterochaetus

were excluded from the total density (Figures 26 through 28), macrobenthic densities along the Patuxent were similar to those reported for similar habitats in other estuaries.

Macrobenthic biomass declined rapidly between stations 8 and 10 (Figures 23 through 25). Upstream of station 10, the biomass of the stocks were only a few percent of downstream biomass levels. The clam, Macoma balthica, was the major contributor to macrobenthic biomass. Downstream of station 9, M. balthica generally accounted for about 90% of benthic biomass. Its biomass declined rapidly upstream of station 9, and adult M. balthica were not observed above station 10. When the biomass of M. balthica was excluded from the totals (Figures 23 through 25, 29, and 30), macrobenthic biomass still declined rapidly at the boundary of oligohaline salinities.

Because Tubificodes heterochaetus was a very small organism and weighs only about 0.016 mg (ash-free dry weight) per individual, the high standing stocks of oligochaetes in the immediate discharge region (stations 7, 8, and 9) contributed only 1 to 2% to total macrobenthic biomass (0.2 to 0.3 g of biomass per m²).

The spatial distribution of macrobenthic biomass in the Patuxent estuary was generally similar to patterns reported for similar sediment types of other tributaries of the Chesapeake Bay or for other temperate zone, western Atlantic estuaries where bivalves are the dominant members of the benthic community. Biomass generally declined greatly in the transition zone between mesohaline and oligohaline salinities (e.g., Pfitzenmeyer 1970, 1973; Tenore 1972; deFur 1973; Boesch 1973, 1974, 1977; Ecological Analysts, Inc. 1974; Polgar et al. 1975; Redding and Cory 1975; Boesch et al. 1976; Calder et al. 1977; Haire 1978; Lippson et al. 1979).

Figures 31 through 38 summarize the spatial distributions of the density and biomass of numerically dominant macrobenthic species (except Macoma balthica) observed during the comprehensive surveys. Figures 39 through 42 summarize the spatial distribution of the M. balthica standing stock during the surveys.

Standing stocks (density and biomass) of eurytolerant marine species (e.g., Eteone heteropoda, Glycinde solitaria, Heteromastus filiformis, Macoma phenax, Mya arenaria, Nereis succinea, and Streblospio benedicti) decreased rapidly in the transition zone between mesohaline and oligohaline salinities during high flow conditions (Figures 31 through 38). These declines appeared to be related to species-specific tolerances to low salinity. The estuary-wide distribution of eurytolerant marine species was not related to prevailing salinity patterns during low flow/high salinity conditions (Figure 33). During low flow conditions, the eurytolerant marine species were much farther upstream than during high flow periods, and frequently had a peak in their standing stock size near the upstream extent of their range (e.g., Streblospio benedicti in Figure 33). In the lower estuary, abundances of the eurytolerant marine species generally decreased between spring and fall; whereas near the upstream limits of their range, abundances increased between spring and fall (Figures 31 through 38).

Statistical analyses of the estuarine-wide survey data confirmed our previous speculations, indicating that during high flow periods (April 1978 and September 1979), much of the spatial variation in abundances of the eurytolerant marine species could be accounted for by spatial variation in salinity (Table 6). During the low flow period (October 1978), spatial variation in abundances of

Macoma phenax and Streblospio benedicti was not strongly related to any of the measured physical factors. Spatial variability for one eurytolerant marine species, Streblospio benedicti, was more strongly related to sediment characteristics and temperature than to salinity during all sampling periods (Table 6).

Regression coefficients obtained from multiple linear regression analyses (Table 7) were used to predict abundances for the eurytolerant marine species (Figures 43 through 46). Since none of the samples that were used to develop these models were from regions of the estuary affected by plant operations, large deviations between predicted and observed abundances in the discharge area were considered indicative of power plant effects, and the relative size of any deviation was one means to determine the relative magnitude of plant effects. These statements are true for all predicted values presented in this section. Deviations between predicted and observed values for the eurytolerant marine species were generally not large enough to suggest power plant effects (Figures 43 through 46). In April 1978, actual densities of Heteromastus filiformis were higher than predicted in the affected region (Figure 43) and at the upstream and downstream reference stations nearest the plant. Thus, the higher-than-predicted standing stocks of H. filiformis in the affected area cannot be completely attributed to plant operations. These differences probably resulted from trying to apply linear models to characterize H. filiformis stocks in a nonlinear portion of their distributional curve. Also, during April 1978, actual densities of Macoma phenax were lower than predicted in the affected region and at several reference stations (Figure 44). This finding also suggests that the model applied was not a good predictor of M. phenax stock size at the plant site or in upstream reference areas. Differences

between predicted and observed abundances of M. phenax were not evident when the April and May data were combined (Figure 44). In general, the models developed for the study appear to accurately describe the spatial distribution patterns of the eurytolerant marine species, except in cases when biological distributions changed rapidly and in a nonlinear manner within small ranges of the physical factors monitored.

In the lower estuary, abundance of the eurytolerant marine species generally increased to a maximum in the spring, followed by summer and fall mortalities, leading to an annual minimum in fall. In the upper estuary, their spring abundances were very low or zero (Figure 31) because spring salinities there were generally too low for most of these organisms. As river flows decreased and salinities increased in the upper estuary between spring and fall, their stock sizes increased to a maximum just downstream of the oligohaline boundary, particularly for those species having major reproductive activity during summer (e.g., Macoma phenax and Streblospio benedicti). The timing difference in recruitment for the eurytolerant marine species in the upper and lower estuary obscured direct relationships between prevailing salinities and standing stock size. Thus, during low flow periods, other physical factors (such as temperature or dissolved oxygen levels, which varied longitudinally during low flow conditions) were better factors for predicting the estuarine-wide distribution patterns of their standing stock abundance.

The species in the Patuxent that are generally classified as estuarine are Cyathura polita, Leptocheirus plumulosus, Macoma balthica, Scolecoides viridis, Tubificoides heterochaetus and the unidentified nemertean species. The density and biomass of L. plumulosus and M. balthica followed patterns

similar to those observed for eurytolerant marine species (Figures 31 through 38). Standing stocks of the other estuarine species were generally maximum between stations 4 and 8 near the downstream limits of the oligohaline zone in high flow periods. During low flows, the abundance maximum of this group was farther upstream near stations 9 and 10. The classical pattern generally reported for estuarine species, where their density is maximum in the middle region of an estuary, was only rarely observed in the Patuxent (e.g., as for Cyathura polita in April and October 1978).

Statistical analyses of the comprehensive survey data for the estuarine species are summarized in Tables 8 and 9 and Figures 47 through 52. A relatively large proportion (20 to 60%) of the longitudinal variation in abundance of this group was unaccounted for by the physical/chemical factors monitored. In addition, we did not detect any relationship between the physical/chemical factors and the spatial distribution of some of the estuarine species (Table 8). Salinity accounted for a major proportion of the spatial variation for only one species, Macoma balthica. Spatial variability in the other physical/chemical factors monitored was a more important determinant of the longitudinal distributional patterns of the estuarine species than it was for eurytolerant marine species. Actual densities of some of the estuarine species were higher than predicted densities, particularly in the middle region of the Patuxent (i.e., Cyathura polita and Leptocheirus plumulosus in April and October 1978; Macoma balthica in April and October 1978 and September 1979; unidentified nemerteans in April 1978). This was probably because physical/chemical factors were not the major environmental factors controlling standing stock size of these species at the most downstream station used to generate the models. In

downstream mesohaline areas, predation by demersal fish and crabs is one of the major factors controlling standing stock size. Since the models did not incorporate predation intensity (Holland et al. 1980a), they consistently underestimate standing stock size of these species in the affected region (Figures 46 through 53). The models cannot explain the higher-than-predicted abundances of Tubificodes heterochaetus in September 1979. This species is not a frequently observed item in the diets of Patuxent demersal feeding fish (Homer et al. 1979). Thus, the differences between actual and observed abundances of T. heterochaetus must be attributed to plant operations.

As was the case for the eurytolerant marine species, very little of the spatial variation in abundance of the estuarine species was accounted for by physical/chemical factors during the low flow period (October 1978). The reasons for this lack of correlation were not entirely clear. But, one reason could be that the eurytolerant marine species compete with the estuarine species for the same resources when they penetrate upstream areas during low flow/high salinity conditions. Also, during low flow periods, populations of animals such as demersal fish and crabs that prey on estuarine species were more abundant in the lower estuary and occurred farther upstream. Increased predation pressure during low flows could obscure relationships between physical/chemical factors and the observed distributions of estuarine organisms (Homer et al. 1979).

We could separate standing stocks of Macoma balthica into year classes, the spatial distributions which are summarized in Figures 39 through 42. During the 1978 surveys (Figures 39 and 41), the 1977 year class dominated both density and biomass of M. balthica stocks upstream of station 5. Downstream of station 3, the 1976 year class dominated. The 1978 year class (i.e.,

young-of-the-year) appeared to experience the highest survival rates and highest growth rates near the plant site in the middle reaches of the estuary. During the September 1979 survey (Figures 40 and 42), M. balthica had a similar distribution pattern. Highest stocks (and presumably highest survival and productivity of young-of-the-year and all year classes) were observed between stations 4 and 8.

The upstream (i.e., low salinity) limit of mature Macoma balthica (> 1 year old) was between stations 9 and 10. The literature suggests this clam cannot survive in salinities below 2.5 ppt for extended periods (Castagna and Chanley 1973), and salinities were consistently less than 2.5 ppt above station 10 during high flow periods (e.g., Lacy and Krueger 1978a, 1978b, 1979). Thus, the upstream limit of M. balthica appeared to be controlled by prevailing salinity patterns.

The mean age-specific shell lengths of Macoma balthica were larger in the discharge region (stations 7 through 9) than at downstream sample sites during all the comprehensive surveys (Table 10), which suggests that M. balthica grew at a faster rate and attained a larger size in the thermally affected region than downstream.

Table 11 summarizes the growth rates, asymptotic size (maximum shell length), and mortality rates calculated for Macoma balthica in the Patuxent. M. balthica reached approximately 85 to 90% of its asymptotic length within the first two years. Growth rates increased with decreasing salinity, with highest rates near the upstream limits of its range. Annual growth rates along the Patuxent were significantly ($P < 0.05$) correlated with mean annual salinity but not with any of the other physical/chemical factors. M. balthica

also reached maximum sizes near the upstream limits of its range, but size was not correlated with mean annual salinity, water temperature, or any of the other physical/chemical factors monitored.

Macoma balthica mortality rates did not vary in a systematic pattern along the estuarine gradient and were not correlated with any of the measured physical/chemical factors (Table 11). Some of the lowest mortality rates occurred near the upstream limits of its range. Highest mortality rates occurred at station 5 in the middle of the estuary.

Growth data for Patuxent Macoma balthica were compared to growth data for M. balthica from various other latitudes (Table 12). Clearly, its growth rate and asymptotic size increased with increasing temperature and was inversely related to latitude. Thus, temperature appears to explain much of the variability in M. balthica growth rates between widely separated geographic zones, and salinity appears to explain much of the variation in growth rates on local and regional scales.

Abundances of macrobenthic species characteristic of tidal fresh waters (e.g., Gammarus sp., Limnodrilus hoffmeisteri, and Tenebrionidae larvae) increased in an upstream direction, with maximum densities generally at the farthest upstream station (station 12 or 22 depending on the survey; Figures 31 through 38). The downstream limits of these species did not fluctuate significantly with changes in freshwater flow (Figures 31 through 38). However, they occurred farther downstream than would be anticipated from distributions reported in similar habitats of other portions of the Chesapeake Bay (e.g., information on the Potomac estuary in Haire 1978; Lippson et al. 1979). This may have resulted from the proximity of freshwater areas in small tributaries of the Patuxent to many of our main-stem sampling locations.

Statistical analyses of the comprehensive survey data for the freshwater species are summarized in Tables 13 and 14 and Figures 53 through 55. Spatial variability in salinity generally accounted for most of the spatial variation in abundances of this species group (Table 13). Mechanical properties or carbon content of sediments were not important factors in their spatial distribution because these sediment properties were relatively homogeneous in the upper portions of the Patuxent sampled. Properties of the overlying water body, such as temperature and dissolved oxygen, were the only physical/chemical factors other than salinity that accounted for a significant amount of the spatial variation in the tidal freshwater species (Table 13).

Figures 53 through 55 compare the observed and predicted spatial distributions of standing stocks of tidal freshwater species. The actual abundances of Limnodrilus hoffmeisteri were consistently higher in the discharge region than predicted and, on one occasion, suggest a power plant effect on this species. For the other species in this group, the actual and predicted abundances in the discharge region did not suggest power plant effects. In general, the models developed for the survey appear to accurately describe the spatial distribution pattern of the freshwater species group.

The unusually high and, in some cases, larger than predicted abundances of oligochaetes (Limnodrilus hoffmeisteri and Tubificoides heterochaetus, Figure 3) at the discharge site (stations 7, 8, and 9) appear to be related to power plant operations, based on the following evidence:

- Peaks in their standing stocks occurred near the discharge site regardless of environmental conditions (e.g., flow, salinity). Their density maxima did not vary with flow regimes or salinity; however, the peak abundances of most other species shifted longitudinally with changes in flow regimes and salinity.

- Oligochaete abundances at the terminus of the Chalk Point discharge canal approached 10 times the levels observed in comparable habitats of other tributaries of the Chesapeake Bay and decreased rapidly upstream and downstream of the discharge canal terminus to the levels reported for similar habitats in other regions of the Chesapeake Bay system (e.g., Diaz, 1980; deFur 1973; Ecological Analysts, Inc. 1974). Furthermore, the changes in oligochaete density in the discharge region of the Chalk Point SES did not appear to be totally the result of natural variation in salinity since they occurred over much smaller ranges of salinity (1 ppt or less) than would be expected.
- Maximum densities of Limnodrilus hoffmeisteri were noted at the discharge site and in tidal freshwater areas. Bimodal distributions of this species have not been previously reported in other regions of the Chesapeake Bay. Maximum densities of L. hoffmeisteri are generally near the transition zone between oligohaline and tidal freshwater habitats (e.g., Diaz, 1980), and if stations in the thermally affected region (stations 7, 8, and 9) are omitted from the plots of the estuarine-wide distribution of L. hoffmeisteri, a single peak in stock size occurred in the upper estuary (Figure 56).
- If stations in the discharge region (stations 7, 8, and 9) are omitted from plots of the longitudinal distribution of Tubificodes heterochaetus, the distribution patterns of this species shifted with changing flow regimes (Figure 56), a response pattern that approximates what would be expected.

Based on this evidence, Tubificodes heterochaetus would likely have attained maximum abundances somewhere near the oligohaline-mesohaline transition zone (i.e., the discharge region) even if the Chalk Point plant were not operating there. However, without power plant operations, the abundance of T. heterochaetus in the discharge region would probably be reduced from current levels and would fluctuate longitudinally in response to changes in freshwater flow (see Figure 56); Limnodrilus hoffmeisteri would probably have only one density maximum in tidal freshwater habitats.

Even though the means by which power plant operations at the Chalk Point SES enhanced oligochaete populations in the discharge region is not clearly understood, there are some possible explanations. Estuarine oligochaetes are primarily deposit feeders, obtaining their nutrition from bacteria and

other microbiota colonizing sediment particles and detritus (Fenchel 1972; Lippson et al. 1979; Diaz 1980). In addition, temperature is an important factor controlling their reproductive success (fecundity) and productivity (growth and survival of young) as well as the productivity of their food organisms. It is possible that increased temperatures from the thermal discharges and organic enrichment from entrainment mortalities of plankton could indirectly stimulate oligochaete reproduction and growth in the thermally affected region by enhancing the productivity of their food organisms. Furthermore, since oligochaetes are not generally considered to be important food items in the diets of predatory finfish or crabs (Pfitzenmeyer 1973; Chao and Musick 1977; Homer and Boynton 1978), increases in their standing stocks related to plant operations would not likely be reduced by predation (Holland et al. 1978; Holland et al. 1980a). Standing stocks of some other deposit feeding organisms were also larger at the power plant (Holland et al. 1979).

Factors resulting in the higher density and biomass of Macoma balthica in the discharge region (stations 7, 8, and 9) are also not completely understood. However, the available evidence indicates that the larger stock sizes in the discharge region were not related to plant operations, but to other environmental conditions, particularly salinity and the factors that vary along the estuary in some predictable manner with salinity. The high growth rate in the discharge region appeared to be the major factor contributing to the increased M. balthica biomass there. However, since growth rates of M. balthica were also higher in the discharge region than in other areas of the Patuxent during the preoperational period (Figure 57), their greater biomass in the discharge region related to high growth rates must have been due to natural factors rather than plant operations.

c. Meiobenthic Distribution

Meiobenthic densities in the main stem of the Patuxent were principally composed of nematodes (Tables 15 through 17), with other meiobenthic taxa (e.g., harpacticoid copepods, ostracods, foraminiferans, juvenile oligochaetes) making up only a small portion. Qualitatively, this finding is in agreement with information on other estuaries (e.g., Coull 1975). However, meiobenthic densities for the July 1979 survey were lower by approximately an order of magnitude in the main stem of the Patuxent than densities reported for other similar estuaries. The reasons for this were not clear, especially since the July densities of meiobenthos in Osborn Cove (a protected location in St. Leonard's Creek, a tributary of the Patuxent) were similar to literature values (Table 16). In addition, more meiobenthic taxa were observed in the Osborn Cove meiobenthic community than in the Patuxent main stem (Table 16).

Because meiobenthic samples from Osborn Cove and the Patuxent main stem were collected in the same manner, the differences in abundances and number of taxa cannot be attributed to sampling inconsistencies. However, salinities at Osborn Cove were generally 3 to 6 ppt higher than any of the main stem sampling stations, which may account for the larger and more diverse communities there (e.g., Coull 1975).

Figures 58 and 59 summarize the changes in densities of the meiobenthic nematodes, oligochaetes, and harpacticoid copepods along the main stem of the Patuxent during a warm and cold season. Tables 18 and 19 and Figure 60 summarize the results of stepwise linear regression analyses for density variation of numerically dominant meiobenthic taxa for each of the surveys conducted. Because only six stations (three reference and three affected) were sampled for meiobenthic organisms, regression analysis was accomplished on the entire

data set as well as on just the data from reference stations. The only physical/chemical factor accounting for significant variation in nematode density was the silt-clay content of sediments (Tables 18 and 19). Salinity accounted for significant amounts of spatial variation in the density of meiobenthic oligochaetes and harpacticoid copepods (Tables 18 and 19).

During the warm sampling period, meiobenthic oligochaete densities decreased upstream and downstream of the discharge region in a pattern similar to that previously discussed for macrobenthic oligochaetes. Meiobenthic oligochaete abundances (adjusted for salinity and the silt-clay content of sediments) were significantly different among stations. No significant differences were observed between their adjusted abundances at station 41 and reference stations or between reference stations upstream and downstream of the discharge canal terminus. However, adjusted data on their abundance at station 9 was significantly higher than at all other stations; and at station 10, was significantly lower than other stations. During the cold sampling period, oligochaetes were only a small component of the meiobenthic community, so station-to-station differences were not evaluated for this season.

Based on literature information, nematode densities should increase with increasing salinity (e.g., Coull 1975; Capstick 1959). However, in both the July and January estuarine-wide surveys, a greater portion of the variability in nematode abundances was accounted for by the silt-clay content of sediments than by any of the other physical/chemical factors monitored (Table 19; Figure 60). After adjustment for the silt-clay content of the sediments, no significant differences were detected in nematode standing stocks among stations.

Harpacticoid copepod densities varied along the estuarine gradient, and their standing stock size decreased with decreasing salinity (Figure 60).

After adjustment for variation in the January stock size due to salinity, there were no significant ($P < 0.05$) differences in stock size among stations. Variation among replicate meiobenthic samples was large. Some of this variation may have been due to the sampling techniques (meiobenthic samples were not, as would be ideal, undisturbed cores of bottom sediments, but were 10-m^2 subsamples of a 200-cm^2 box-core sample). It was impossible to subsample the box corer directly. Box core samples first had to be emptied into a dishpan before meiobenthic samples could be collected. Any excess water trapped in the top of the corer, would have disturbed the surface sediments during the extraction process; or, if the box corer was pushed too far into the bottom, surface sediments would have been disturbed before the subsample was removed from the samples. Although we made every possible effort to minimize disturbance, some disturbance may still have caused variation. Undisturbed cores should be used for any future meiobenthic work.

d. Microbenthic Distribution

Because some of the benthic data collected during 1978 and 1979 by Patuxent benthic studies (see Holland et al. 1979) suggested that microbenthic standing stocks, particularly bacteria, may be more productive and more abundant in the discharge region than in reference areas, an effort was undertaken to develop a technique that could be used routinely to determine the effects of power plant operations on microbenthic abundance. Estimation of ATP in sediments has been suggested as a useful measure of bacterial carbon in sediments of aquatic habitats (e.g., Ausmus 1973; Christian et al. 1974), especially if extraction techniques can recover 90% or more of the ATP in sediments (Bulleid 1978). However, ATP extracted from sediments contains not only

bacterial ATP but also meiobenthic and macrobenthic ATP, and the information necessary to partition bacterial ATP from other sources of ATP has only recently been obtained (e.g., Sikora et al. 1977; Yingst, in press).

During the July 1979 benthic cruise, a survey of sediment-borne ATP levels was conducted along the main stem of the Patuxent and in Osborn Cove using Bulleid's extraction technique. Main-stem ATP samples were taken from muddy sediments. Osborn Cove samples were taken from the three major sediment types (sand, muddy-sand, and mud). Estimates of macrobenthic and meiobenthic abundances were obtained with each ATP sample. Results of this study were summarized in Appendix B of a previous annual report (Holland et al. 1980b).

ATP levels were highest in surface sediments, decreased with increasing depth in sediments (Tables 20 and 21), and at 5 cm and 25 cm below the sediment surface, were about 40% of surface levels. ATP levels in surface sediments and at other depths were significantly ($P < 0.10$) different at all locations except the two sampling sites farthest upstream (stations 9 and 10). Other studies investigating changes in ATP levels with depth reported similar patterns (e.g., Christian et al. 1974; Yingst, in press). ATP probably decreases with depth because bacterial densities decline with depth (Dale 1974). Stocks of the meiobenthos and microbenthos other than bacteria also decline with depth (e.g., Coull 1975; Yingst, in press). At a 10-cm depth, stocks of all these benthic components are generally about 50% of stock sizes in surface sediments.

Over 98% of the spatial variation in surface-sediment ATP was accounted for by the spatial variation in the silt-clay content and available carbon content of sediments (Figure 61a). However, both of these factors were highly correlated with salinity, and salinity accounted for 83% of the variation in surface-sediment ATP levels (Figure 61b). None of the other physical/chemical

factors monitored accounted for as much of the spatial variation in ATP as salinity, which was thus the most important factor. When salinity, silt-clay content, and available carbon content were all incorporated in a single regression equation, over 99% of the spatial variability in ATP levels was accounted for.

To partition the measured ATP levels into the amounts contributed by macrobenthos, meiobenthos, and microbenthos, we used estimates of stock size and average literature values for ATP levels in the benthic species that dominate Patuxent benthic assemblages (Table 21). No macrobenthic organisms were observed in any of the main-stem sediment samples processed for ATP. Macrobenthic organisms that were likely in these samples but not detected (e.g., small oligochaetes) were probably at densities of less than 1 per gram dry weight of sediment, or approximately 2 individuals per cm^2 . If these organisms were in our ATP samples, they would not have contained more than 200 ng of ATP per individual, and their contribution to the observed ATP totals would be on the order of 0.1 to 0.2 μg ATP per gram dry weight of sediments or between 1 and 16% of surface sediment ATP values (Table 21).

To calculate the meiobenthic contribution to surface sediment ATP, all the meiobenthic organisms observed were assumed to be in the surface layers, and the ATP content per individual meiobenthic organism was assumed to be between 6 and 20 ng (Sikora et al. 1977; Yingst, in press). Based on these assumptions, the calculated meiofaunal contribution was 3 to 18% (Table 22). This is considerably lower than the proportion of sediment-borne ATP contributed by the meiobenthos for a protected and undisturbed salt marsh system (Sikora et al. 1977), but agrees with the meiobenthic contribution reported by Yingst (in press) for surface sediments of Long Island Sound.

If the ATP not accounted for by the macrobenthos and meiobenthos was assumed to be mostly bacterial ATP (living benthic diatoms are not a major constituent of Patuxent benthic assemblages), then bacteria accounted for 66 to 96% of the main-stem ATP. Furthermore, if the average ATP per bacterial cell is assumed to be equivalent to the literature average of 8.8×10^{-16} g ATP per cell (Erkenbrecker, personal communication*), then bacterial densities in surface sediments of the Patuxent should be between 4.7×10^8 to 1.7×10^9 cells per gram dry weight of sediment. These density estimates seem reasonable and are within ranges reported for estuarine sediments when direct counting methods were used (e.g., Dale 1974). If all ATP below 5 cm in the Patuxent is assumed to be bacterial ATP, bacterial density in deeper sediments would be about 10^8 cells per gram dry weight of sediment. This value is also roughly equal to literature values for bacterial abundances in subsurface estuarine sediments (Dale 1974).

Several of the ATP measurements from the deeper sediment layers of the main stem and Osborn Cove appear to be outliers (Tables 20 and 21). This was not unexpected, since we did not take precautions to insure that parts of deep burrowing organisms (e.g., siphons of Macoma balthica) were excluded from these deeper sediment samples, even though no animal parts were observed. Other investigators working with ATP standing stock size in deeper sediments have encountered similar problems.

We do not know why the ATP levels in deeper sediments at station 5 were relatively high. Because ATP levels in deeper sediments decreased upstream and downstream of station 5, this pattern may have been related to some

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biological or physical/chemical factor that varied in deeper sediments upstream and downstream of station 5. Physical/chemical characteristics of the deeper sediments themselves did not vary upstream or downstream of station 5; however, the density of the clam, Macoma balthica, particularly older and larger clams, decreased upstream and downstream. M. balthica reworks sediments down to a depth of 15 to 25 cm during burrowing and feeding, which could stimulate bacterial abundance in the deeper sediments in the Patuxent by ventilating them with water containing oxygen. The ventilation would probably be sufficient to stimulate bacterial growth and standing stock size in deeper sediments. This speculation is supported by our observation that ATP levels of surface and deeper sediments were not different at stations 9 and 10 where densities of M. balthica were lowest.

ATP levels in surface sediments in the discharge area (stations 41, 8, and 9) did not vary from the pattern that could be attributed to ambient salinity and sediment gradients (Figure 61). Thus, there did not appear to be a power plant effect on bacterial ATP levels in the nearfield region.

The ATP data collected from Osborn Cove were an order of magnitude lower than values in the estuary or in similar estuarine habitats (Table 21). Density estimates of macrobenthic organisms from Osborn Cove were less than 0.01 individual per gram dry weight of sediment. At these extremely low densities, macrobenthic organisms probably accounted for essentially none of the ATP in surface sediments of Osborn Cove (Table 23). Nematode standing stocks in Osborn Cove were an order of magnitude larger than in the main stem of the Patuxent (30 to 50 nematodes per gram dry weight). Using a conservative estimate of ATP levels per nematode [≈ 3 ng of ATP per individual (Sikora et al. 1977)], nematodes accounted for 90% of the ATP in surface sediments of the mud

habitat and 100% of the ATP observed in the sand and muddy-sand habitats. Based on these calculations, essentially none of the ATP in Osborn Cove sediments was due to the microbenthos. It seems unreasonable that such large nematode stocks could be maintained without large bacterial standing stocks. The bacterial stock size required to support the nematode stock estimated for Osborn Cove, based on the assumption that each nematode would require between 10^6 and 10^7 bacterial cells per day for growth and reproduction (Tietjen and Lee 1973), would be on the order of 10^8 or 10^9 cells per gram dry weight of sediment. Bacterial standing stocks of 10^8 and 10^9 cells per gram dry weight sediment would equal about 1.0 to 1.5 μg ATP per g dry weight of sediment (Table 23).

Thus, the ATP measurements from Osborn Cove samples were apparently in error. If these ATP values were assumed to be off by a factor of 10 (i.e., by the location of the decimal point), then the ATP levels there would be within ranges reported for similar habitats in other estuaries, with the meiobenthos accounting for between 18 and 25% of ATP in surface sediments and bacteria accounting for most of the remaining 75 to 80%. If this were the case, and if bacterial ATP were converted to density values, bacterial densities in Osborn Cove would be approximately 10^9 cells per gram dry weight of sediment. This is roughly equivalent to the bacterial stock size required to support the feeding pressure by nematodes (Table 23). Because these preliminary and speculative calculations suggest that ATP estimates from Osborn Cove samples were off by an order of magnitude, we recommend that this study be repeated at some later date.

The ATP data indicate several important findings.

- If ATP values observed in the Patuxent main stem were converted to carbon by using standard conversion ratios (250:1 for bacteria and

150:1 for other benthic organisms) it appears that most of the carbon in Patuxent sediments was not living carbon. Living carbon was only 0.1% of each gram dry weight of sediment, whereas total carbon was between 10 and 14% of each gram dry weight of sediment. Most of the carbon in Patuxent sediments is apparently dead carbon (e.g., detrital material from upstream marshes).

- Power plant operations at Chalk Point have not enhanced bacterial standing stocks in the discharge region.
- Living carbon in the sediments of the study areas was not enriched by nutrient and organic inputs from upstream sources. In fact, the living carbon in sediments decreases in an upstream gradient.

2. Special Studies

a. Monthly Sampling Program

The monthly sampling program was designed to obtain estimates of short-term temporal variability of macrobenthic standing stocks in the nearfield region. This information was also used to determine if spatial differences observed in macrobenthos between the discharge area and downstream reference areas during the comprehensive estuarine-wide surveys also occurred when samples were taken at shorter intervals.

Figures 62 through 71 summarize the monthly biomass and density data on the most frequently collected macrobenthic species between April 1978 and July 1979. Temporal variation in biomass and density of the total benthic community over the same period is summarized in Figure 72.

Three species (Leptocheirus plumulosus, Nereis succinea, and Scolecolepidus viridis) had population patterns that suggested their standing stocks were controlled by environmental factors that varied seasonally, such as temperature, predation pressure, and river flows (Figures 62 through 64). The density and biomass of these species was greatest during winter and early spring when temperatures and salinities were low and the abundances of bottom

feeding predators were at their annual minimum. Their densities and biomass were lowest during summer and early fall when predator populations, temperatures, and salinity attained their annual maximum. All of these species are important food items in the diets of bottom feeding predators (Homer et al. 1980; Hixon 1978a, 1978b, 1979).

Temporal patterns for Leptocheirus plumulosus, Nereis succinea, and Scolecoides viridis were generally similar at nearfield and reference stations. Station-to-station differences in their density were attributed to longitudinal differences in natural environmental factors and not to plant operations. For example, S. viridis was consistently more abundant in the discharge region than at downstream reference areas, but these differences could not be attributed to power plant operations because S. viridis standing stocks generally increase from higher to lower salinities.

The temporal distribution of Cyathura polita and Heteromastus filiformis over the two-year study period appeared to respond more to variations in salinity than to seasonal changes in other environmental factors (Figures 65 and 66). For example, their maximum standing stocks were farther downstream during the low salinity/high flow period (fall 1979) than during the higher salinity/normal flow period (fall 1978). C. polita reproduces in spring and summer, as indicated by the percentage of females bearing young and the proportion of young in the population (Table 24). Since this species only lives for 12 to 18 months (approximately the time course of this study) and was a major item in the stomach contents of seasonally abundant finfish (Homer et al. 1980), mortality and reproductive success during the summer and fall (the time of maximum predation pressure) must have been roughly equivalent. There were no differences in the temporal patterns of C. polita standing stocks between

the discharge areas and reference areas that could be attributed to plant operations. Temporal patterns for the species among stations were generally related to among-station variability in physical/chemical factors (see previous discussions on regional surveys).

Heteromastus filiformis also has an annual population cycle. It was only infrequently observed in stomachs of demersal feeding fish (Homer et al. 1980) and was generally thought to be reproductively active over much of the year. In this study, the intolerance of H. filiformis to salinities below 4 to 5 ppt appeared to control its temporal distribution pattern. For example, the decline in its stocks at station 5 between July and November 1979 was directly attributed to a drop in salinity. A similar decline in abundance was not noted farther downstream at station 3 where salinities remained above 4 to 5 ppt (Figure 66). No power plant effects on the temporal patterns of H. filiformis were apparent.

We could see no clear relationships between the temporal variation in the standing stocks of Limnodrilus hoffmeisteri and Tubificodes heterochaetus and environmental conditions such as salinity, temperature, or seasonal predation pressures (Figures 67 and 68). These two species were not major food items in the diets of demersal feeding fish (Homer et al. 1980), and previous analyses and discussions indicate their distribution near the plant site was more related to plant operations than to other environmental factors.

The temporal pattern of Macoma phenax in the discharge region (stations 7 and 8) was very different from the pattern at downstream reference areas (stations 5 and 6; Figure 69). Abundances at the discharge site seemed to be related to seasonal changes in salinity. In the downstream reference areas where salinity was always sufficient for survival of M. phenax,

populations pulsed in spring (April to May) and declined through the rest of the year (Figure 69). Power plant operations did not appear to affect the temporal distribution of M. phenax.

The temporal distribution of Macoma balthica standing stocks was similar in the discharge and reference areas (Figures 70 and 71). As discussed previously, the station-to-station differences in the standing stock size of this species between the discharge region (stations 7 and 8) and downstream reference areas (stations 5 and 6) were due to differences in recruitment success, growth rates, and mortality rates due to salinity and not power plant operations. Unfortunately, temporal patterns in M. balthica biomass were not as clear as were temporal patterns in their density because the biomass per individual M. balthica varied seasonally (Figure 73). The seasonal change in weight per individual M. balthica was probably related to the production and release of gametes.

Patterns of temporal variation in total macrobenthic community characteristics were generally similar at stations near the discharge site (stations 7 and 8) and at downstream reference areas (stations 5 and 6; Figure 72). There was little seasonal variation in macrobenthic biomass (Figure 72a) except when the biomass of the long-lived and large clam, Macoma balthica, was excluded (Figure 72b). The only obvious power plant effect on total macrobenthic community characteristics was on total abundance (primarily oligochaetes) at station 8.

b. Caging Experiments

1978 Experiment

Biological data collected during the 1978 caging experiment are presented in Tables 25 and 26. These predator exclusion experiments were not as

successful as experiments conducted for PPSP at Calvert Cliffs, possibly because predatory crabs got into the cages and were not detected until they had affected the stock sizes of macrobenthic populations inside the cages. A blue crab was found inside the cage at Teague Point near station 5 during May 1978, one month after the experiment started. Mud crabs (Rhithropanopeus harrisii) were significantly more abundant inside the discharge area cage during the June, July, and August 1978 sampling period than they were at the uncaged reference area. Thus, only the data collected from April through May 1978 at the discharge site could be used to evaluate the effects of predator exclusion on macrobenthic communities of the Patuxent estuary (these data are summarized in Figure 74). The sediment data collected inside the cages and in the adjacent uncaged reference area do not indicate there was a large effect of caging on sediment characteristics (Table 27).

Standing stocks of 7 of the 10 macrobenthic species for which ANOVA's were performed were significantly higher inside the caged discharge area after one month than they were in the adjacent reference area (Table 26; Figure 74). Only one species, Corophium lacustre, was significantly more abundant in the reference area. Most macrobenthic species were reproductively active during April and May (Appendix A), and their reproductive success inside the cage was apparently more successful than in the uncaged area (Table 26; Figure 74). Furthermore, most of the species with significant increases in standing stock inside the caged area (e.g., Cyathura polita and Leptocheirus plumulosus) were organisms that were frequently observed food items in the stomachs of bottom feeding finfish (Hixon 1978a, 1978b, 1979; Homer et al. 1980).

Because background information was lacking on the effect that predator enclosure would likely have on benthic communities, interpretation of caging data collected at station 5 and in the discharge region after June was not possible. However, with the crabs in the cage, total standing stocks there were generally slightly lower or similar to standing stock sizes in the adjacent uncaged reference areas (Table 25), and just as many species were more abundant in uncaged reference sites as were more abundant in the caged areas.

Although the results of the 1978 caging experiments were far from definitive, they did indicate that the standing stocks of macrobenthic species in the Chalk Point region were affected by predation. Furthermore, it was apparent from the temporal changes in macrobenthic stocks discussed in the previous section, and from the fish stomach-content data, that the role of predators in controlling macrobenthic abundances was qualitatively similar to that in the Calvert Cliffs region (Holland et al. 1980b). However, the magnitude of predation effects on Patuxent stocks did not appear to be as large as at Calvert Cliffs.

1979-1980 Experiment

In hopes of clarifying results of the 1978 predator exclusion experiments and of obtaining data that could be used to determine the relative magnitude of interactions between bottom feeding predators and benthic organisms, a series of field experiments were conducted from September 1979 through May 1980 to evaluate the effects of predator exclusion on:

- Naturally occurring benthic communities
- Meiobenthic and macrobenthic recolonization processes.

These experiments were started in late summer (September) because the predatory crabs, Rhithropanopeus harrisii and juvenile Callinectes sapidus, which we could not exclude by caging in the 1978 experiments, were at or near their annual minimum levels. Standing stocks of bottom feeding fish and adult blue crabs were relatively large through late fall and again in early spring (Homer et al. 1979; Souza et al. 1980).

The cages deployed in 1979 apparently affected sediment characteristics (Table 28). In winter, total carbon content inside the caged area was significantly higher than would have been predicted based on silt-clay content of the sediments (Table 28). Silt-clay content explained about 80% of the variation in total carbon near station 5 (Table 28). Available carbon content in the caged area also increased throughout the experiment, reaching a maximum in May. These results indicate that organic material, probably refractory detritus from adjacent and/or upstream marshes, accumulated inside the cages during colder seasons when microbial activities that degrade them were low. As temperatures increased through spring, bacteria and other microorganisms used this material for a substrate, increasing the available carbon content of sediments inside the cages.

Abundance data collected at the area from which predators were excluded and the adjacent reference area are summarized in Tables 29 and 30.

Results of the ANOVA's and MANOVA applied to the macrobenthic data are in Tables 31 and 32. These analyses indicate that at the start of the experiment in September 1979, there was not a significant difference in macrobenthic community structure (Table 32) or abundance of any of the 13 species for which ANOVA's were accomplished (Table 31) among study sites. Thus, at the start of the experiment, the experimental plots were relatively similar.

Results of the ANOVA's and MANOVA accomplished on the macrobenthic data collected over the entire nine-month study period (September 1979 through May 1980) are presented in Tables 33 and 34. These analyses indicate:

- Predator exclusion had a significant effect on macrobenthic community structure (Table 34) and on the abundance of 4 of 13 species (Table 33). The 4 species (Corophium sp., Hypaniola grayi, Scolecoclepidus viridis, and Tubificoides heterochaetus) were more abundant in the areas from which predators were excluded, but were not particularly important food items in the stomach contents of bottom feeding predators in the area (Homer et al. 1980).
- Sampling month had a significant effect on macrobenthic community structure (Table 34) and on abundance of 9 of 13 species (Table 33). This effect is attributed to seasonal reproductive activity of the species concerned.
- Interaction terms were significant in the MANOVA (Table 34) and for 2 of 13 species (Table 33).

Because sampling month had a significant effect on the experiment, a series of ANOVA's and MANOVA's were applied individually to the data collected at approximately one, six, and nine months after the start of the experiment (October, March, and May on Tables 31 and 32). Sequential analysis of the data by date should remove the effect of sampling month and still allow description and characterization of temporal patterns or trends.

One month after the start of the experiment (October), predator exclusion had significant effects on the abundance of only 1 of 13 species, Scolecoclepidus viridis (Table 31), and did not have a significant effect on macrobenthic community structure (Table 32). However, by March, two species (Corophium sp. and Cyathura polita) were significantly more abundant inside the caged area than in the adjacent uncaged reference area (Tables 29 through 31). The higher abundances of these species inside the caged area resulted in macrobenthic community structure in the caged area being significantly

different from that in the adjacent uncaged reference area. In May, five species (Hypaniola grayi, Limnodrilus hoffmeisteri, Macoma phenax, Scolecopides viridis, and Tubificodes heterochaetus) were significantly more abundant inside the caged area than they were in the adjacent uncaged area, and one species (Macoma balthica) was significantly more abundant in the uncaged reference area than in the caged area (Tables 29 through 31). These differences resulted in highly significant community-level differences between the uncaged reference area and the caged area (Table 32).

Macrobenthos Recolonization Experiment

The results of the experiment examining the effects of predator exclusion on recolonization by macrobenthic organisms is summarized in Figure 75. The results of the ANOVA's and MANOVA's performed on the data collected from September 1979 through May 1980 (Tables 35 through 38) indicated:

- Sampling month had a significant effect on macrobenthic community structure in recolonization trays (Table 36) and on abundance of 16 of 28 taxa (Table 35). Taxa that did not show a month effect were generally rare organisms (e.g., dipteran pupae, Tanaidae larvae, and the unidentified leech species) or were ending reproductive activity at the beginning of the experiment (e.g., Macoma phenax, Nereis succinea, and the unidentified nemertean species).
- Exclusion of predators did not have a significant effect on macrobenthic community structure in recolonization trays (Table 36), and had a significant effect on the abundance of 7 of 28 taxa. Several of the taxa which had higher abundances inside the caged area (Hypaniola grayi, Limnodrilus hoffmeisteri, Rangia cuneata, and Tendipedidae larvae) were not important food items in the stomach contents of bottom feeding predators (e.g., Homer et al. 1980). Cyathura polita, which was an important food item in predator diets, was more abundant in the uncaged reference area.
- Significant interaction terms occurred for one of the MANOVA statistics and for 5 of the 28 taxa (Tables 35 and 36).

Because of the significant effect that sampling month had on the experiment, a series of ANOVA's and MANOVA's were accomplished individually on the recolonization data collected approximately one, three, six, and nine months after the start of the experiment (October, December, March, and May). We anticipated that when the data were analyzed in this manner, the effect of sampling month would be removed and the number of significant interaction terms would be reduced. Furthermore, sequential analysis of each month's data would allow the description and characterization of temporal patterns or trends.

Results of the ANOVA's and MANOVA comparing the data collected over the entire nine-month period are presented in Tables 37 and 38. These analyses indicate:

- Exclusion of predators had a significant effect on macrobenthic community structure in recolonization trays one (October) and nine (May) months after the start of the experiment (Table 38).
- Exclusion of predators had a significant effect on abundance of only 2 of 19 taxa in October (Table 37). Both taxa (Corophium sp. and Cyathura polita) were more abundant in the uncaged reference area and were items of food in the diets of bottom feeding predators. Thus, the abundance should have theoretically been higher in the caged area.
- Predator exclusion did not have a significant effect on abundance of any of the 18 taxa in December and on only one species (Cyathura polita) in March (Table 37). C. polita was more abundant at the reference site than in the caged area.
- Predator exclusion had a significant effect on abundance of 6 of 24 taxa in May (Table 37). Four (Gammarus sp., Hypaniola grayi, Limnodrilus hoffmeisteri, and Tendipedidae larvae) were more abundant inside the area from which predators were excluded and two (Rangia cuneata and Tubificodes heterochaetus) were more abundant at the uncaged reference area.

Of the species that were more abundant inside the caged area than in the reference area, only Gammarus sp. is likely to be a preferred food item of bottom feeding predators (Homer et al. 1980). The others are only infrequently

found in the stomach contents of bottom feeding predators. In general, species with higher abundances in recolonization trays inside the cage were deposit feeding organisms that were likely to respond to the organic enrichment in the caged environment.

Meiobenthos Recolonization Experiment

The results of the experiment examining the effects of predator exclusion on recolonization processes of meiobenthic organisms is summarized in Figure 76. Detailed results of analyses on these data are presented in Tables 39 through 45.

Results of the ANOVA's and MANOVA's accomplished for the data collected over the entire nine-month study period are presented in Tables 39 and 40 and indicate:

- The month for sampling did not have a significant effect on meiobenthic community structure in recolonization trays (Table 40). However, there was a significant month effect on the abundance of 14 of 20 taxa analyzed (Table 39). Taxa that did not show a significant month effect were not particularly abundant (e.g., bivalves and bivalve larvae) or would generally not be considered benthic, although they are occasionally taken in benthic samples (e.g., cladocerans). Most of the variation associated with sampling month can be attributed to reproductive activity.
- Predator exclusion did not have a significant effect on meiobenthic community structure (Table 40) and only had a significant effect on abundance of 5 of 26 taxa (Table 39). Taxa showing a predator effect were not particularly abundant organisms, and only harpacticoid copepods were a frequently observed food item in the stomach contents of the bottom feeding predators surveyed. Several taxa were more abundant in the reference site than at the caged area.
- Interaction terms in the MANOVA were not significant (Table 40) and only 6 of 25 taxa had significant interaction terms (Table 39).
- The tray (i.e., replicate) effect was not significant for the MANOVA (Table 40) and was significant for only 4 of 21 taxa (Table 39).

Because sampling month had a significant effect on univariate meiobenthic recolonization processes, a series of ANOVA's and MANOVA's were conducted individually on the recolonization data collected approximately one, three, six, and nine months after the start of the experiment. Analysis of data in this manner was expected to remove the effect of sampling month and reduce the number of significant interaction terms. Furthermore, sequential analysis of each month's data allowed the description and characterization of any patterns or trends in community development.

Results of the ANOVA's and MANOVA accomplished on the data collected approximately one month (October) after the start of the experiment, presented in Tables 41 and 42, indicate:

- Exclusion of predators did not have a significant effect on meiobenthos community structure in recolonization trays (Table 42) and only had a significant effect on abundance of 3 of 19 taxa (Table 41). These 3 taxa, harpacticoid copepods, hydrozoans, and ostracods, were less abundant at the uncaged reference area than in the caged area.
- Tray (i.e., replicate) effects were not significant in the MANOVA (Table 42) and were significant only for 2 of 15 taxa (Table 41). Taxa having significant tray effects had extremely low abundances.

Results of the ANOVA's and MANOVA accomplished on the data collected approximately three months after the start of the experiment are presented in Tables 42 and 43. These analyses indicate:

- Exclusion of predators had a significant effect on meiobenthic community structure in recolonization trays (Table 42) but only affected abundance of 3 of 15 taxa (Table 43). The 3 taxa, ciliates, polychaete larvae, and rotifers (Table 43), and were all more abundant at the reference area than at the caged area. The observed differences and results of this analysis cannot be attributed to predator exclusion.
- Tray (i.e., replicate) effects were not significant in the MANOVA (Table 42) and were significant for only 1 of 11 taxa (Table 43). Taxa showing tray effects occurred in low abundances.

Results of the ANOVA's and the MANOVA applied to the data collected approximately six months after the start of the experiment, presented in Tables 42 and 44, indicate:

- Exclusion of predators did not have a significant effect on meiobenthic community structure in recolonization trays (Table 42) and had a significant effect on abundance of 1 of 16 taxa (Table 44). The taxa showing a significant effect from predator exclusion, harpacticoid copepods, was more abundant inside the caged area than in adjacent uncaged areas and was a frequently observed food item in the stomach contents of demersal feeding fish from the Patuxent (Homer et al. 1980).
- Tray (i.e., replicate) effects were not significant for the MANOVA (Table 42) or any of the 12 taxa (Table 44).

Results of the ANOVA's and the MANOVA's accomplished on the data collected approximately nine months after the start of the experiment are presented in Tables 42 and 45. These analyses indicate:

- Exclusion of predators did not have a significant effect on meiobenthic community structure in recolonization trays (Table 42) and had a significant effect only on abundance of 1 of 11 taxa (Table 45). The taxa showing a significant predator effect, rotifers, was more abundant in the uncaged reference area than in the area where predators were excluded.
- Tray (i.e., replicate) effects were not significant for the MANOVA (Table 42) and were significant for 4 of 11 taxa (Table 45).

Summary

The predator exclusion experiments indicated that benthic predators in the Patuxent did not have as large a role in controlling standing stocks of benthic communities as they did at Calvert Cliffs, a mesohaline area. Although predator exclusion had a significant effect on macrobenthic organisms, it generally did not affect the abundance of species that were important food

items in the diets of bottom feeding fish or crabs inhabiting the area. Rather, benthic species such as Limnodrilus hoffmeisteri and Tubificodes heterochaetus (both very small deposit feeding oligochaetes) and Hypaniola grayi and Scolecoides viridis (both relatively small deposit feeding polychaetes), which were not important food items in the diets of bottom feeding fish, increased in abundance inside the caged areas. Most of these species are organisms found in high abundances in organically enriched areas and are species known to respond to increases in the quality of organic material settling to the bottom. Apparently, the higher abundances inside the areas caged during the 1979-1980 experiment were a response to increases in organic material inside the cages rather than to exclusion of predators. Several factors contributed to these results:

- The region of the Patuxent where the experiments were conducted is just downstream of the zone of maximum turbidity, and much of the detritus from the extensive oligohaline and tidal-freshwater marshes of the Patuxent naturally settles to the bottom here. Apparently, more of this material settled to the bottom inside the cages than in uncaged reference areas.
- Predation pressures were not maximum when these experiments were conducted because fish and blue crab stocks were not at their maximum levels.
- Recruitment pulses of benthic organisms in the Patuxent were not limited to one season. Most benthic species experienced recruitment throughout the spring, summer, and fall (e.g., Table 24). Continual recruitment would indicate that if density-dependent factors are affecting benthic recruitment, then predator exclusion experiments would be a relatively ineffective method of assessing the role of predation in the shaping of benthic communities.

Exclusion of predators did not significantly alter recolonization by meio-benthic or macrobenthic communities in "azoic" sediments. Recolonization sequences inside caged areas were similar to those in reference areas.

There was no evidence to suggest that the absence of a predator effect (i.e., increased abundances of preferred food items inside the cages) could be attributed to undetected predators gaining access to the cages. No fish predators were observed inside the cages, and predatory crabs were not more abundant inside the cages used in the 1979 experiments than they were in the adjacent estuarine habitats. Some small fish, such as Fundulus sp., might have been able to routinely gain access to cages through the mesh. However, Fundulus were not particularly abundant at the study site (e.g., Homer et al. 1979). The absence of a predator effect must be attributed to our inability to detect one had it occurred.

c. Discharge Canal Study

A monthly survey at three mud, sample sites in the discharge canal was initiated in July 1978. Densities of macrobenthic organisms were generally less than 100 individuals per m² during July and August, with only one or two species in each sample. These densities are an order of magnitude lower than occurred in similar sediments in the adjacent estuary. However, by September and October, benthic organisms had repopulated the canal. Densities increased along the canal, with highest densities at the station closest to the terminus. Benthic populations in the discharge canal continued to increase during winter and spring of 1979, but discharge canal standing stocks were never equivalent to those of similar substrate types in the adjacent estuary.

d. Recolonization Experiments

Sediment data collected with recolonization experiments are summarized in Table 28. The total carbon content of sediments in recolonization trays

in the discharge canal were significantly higher than predicted based on the silt-clay content of the sediments.

Macrobenthos

The results of the macrobenthic component of the recolonization experiment are summarized in Figure 75. Detailed results of the analysis are presented in Tables 46 through 55.

Results of the ANOVA and the MANOVA performed on the macrobenthic data collected over the entire nine-month study period are summarized in Tables 46 and 47. These analyses indicate:

- Sampling month had a significant effect on macrobenthic community structure (Table 47) and on 19 of 24 macrobenthic taxa (Table 46). Taxa that did not show a month effect were generally not abundant (e.g., dipteran pupae, Tanaidae larvae, and the unidentified leech species) and/or were ending reproductive activity at the beginning of the recolonization experiment (e.g., Macoma phenax and the unidentified nemertean).
- The source of sediments (discharge canal or adjacent estuary) did not have a significant effect on macrobenthic community structure (Table 47) and did for only 5 of 24 taxa (Table 46). Of the five, one was a fouling organism (Balanus sp.) and one was an epifaunal organism (Palaemonetes pugio). Reasons for a significant effect of sediment source on these taxa are not clear. The other three (Cyathura polita, Rangia cuneata, and Hypaniola grayi) were infaunal organisms and were more abundant in discharge canal sediments than in estuarine sediments.
- The experimental location (discharge canal or adjacent estuary) of the recolonization trays had a significant effect on macrobenthic community structure (Table 47) and on 19 of 24 macrobenthic taxa (Table 46). Taxa that did not show a location effect were rare organisms that occurred in low abundances in recolonization trays.
- Significant interaction terms occurred for all the MANOVA test statistics (Table 47) and for 16 of 24 taxa (Table 46).

Because of the significant effect of sampling month on macrobenthic recolonization processes, a series of ANOVA's and MANOVA's were performed

individually on the recolonization data collected approximately one, three, six, and nine months after the start of the experiment. The data analyzed in this manner were expected to remove the effect of month and reduce the number of significant interaction terms.

Results of the ANOVA and the MANOVA performed on the macrobenthic component of the recolonization data collected one month after the start of the experiment (October 1979), presented in Tables 48 and 49, indicate:

- The source of the sediments (discharge canal or adjacent estuary) used in the recolonization trays had a significant effect on macrobenthic community structure (Table 49) and on 2 of 21 taxa (Table 48). The two taxa, Cyathura polita and Corophium sp., numerically dominated recolonized communities on this sampling date. Both were more abundant in canal sediments.
- The experimental location (discharge canal or adjacent estuary) of the recolonization trays had a significant effect on macrobenthic community structure (Table 49) and on 5 of 21 taxa (Table 48), which were more abundant in recolonization trays located in the estuary than in the discharge canal.
- Interaction terms in the MANOVA were significant for all of the test statistics; however, no significant interaction terms were observed in any of the ANOVAs for individual species.

Results of the ANOVA and MANOVA performed on the recolonization data collected in December, three months after the start of the experiment, are presented in Tables 50 and 51. These analyses indicate:

- The source of sediments (discharge canal or adjacent estuary) did not have a significant effect on macrobenthic community structure (Table 51), and had a significant effect on only 3 of 19 taxa (Table 50). Two (Nereis succinea and Limnodrilus hoffmeisteri) were more abundant in discharge canal sediments and one (Heteromastus filiformis) was more abundant in natural estuarine sediments.
- The experimental location (discharge canal or adjacent estuary) of the recolonization trays did not have a significant effect on macrobenthic community structure (Table 51) but had a significant effect on 9 of 19 taxa (Table 50). Of the nine, only Nereis succinea and Limnodrilus hoffmeisteri had higher abundances in recolonization

trays located in the discharge canal. L. hoffmeisteri was one of the species previously discussed as favoring thermally affected regions of the Patuxent, and N. succinea is a species known to have biological characteristics (e.g., mobility, tolerance to extreme environmental conditions) that make it a successful colonizer of "azoic" sediments (Holland et al. 1977).

- No significant interaction terms occurred in the MANOVA and only 2 of the 19 ANOVA had significant interaction terms.

Results of the ANOVA and MANOVA performed on the macrobenthic recolonization data collected in late February and early March, approximately six months after the start of the experiment, are presented in Tables 52 and 53. These analyses indicate:

- The source of sediments (discharge canal or adjacent estuary) used in recolonization trays did not have a significant effect on macrobenthic community structure (Table 52) and had a significant effect on only 1 out of 21 taxa (Table 53), Balanus sp., an epifaunal fouling organism that would be expected to have limited interaction with the sediment in recolonization trays and was probably limited to inhabiting the walls of the containers. The reason this organism showed a significant sediment effect is not clear.
- The experimental location (discharge canal or adjacent estuary) of the recolonization trays did not have a significant effect on macrobenthic community structure, but had a significant effect on 10 out of 21 taxa. One of the 10 taxa (Tendipedidae larvae) was more abundant in recolonization trays located in the discharge canal. The remaining 9 species were more abundant in recolonization trays located in the adjacent estuary.
- Interaction terms were not significant in the MANOVA and were significant for only 1 of 21 taxa for which ANOVA were performed, Balanus sp.

Results of the ANOVA and the MANOVA performed on the macrobenthic data collected in late May, approximately nine months after the start of the recolonization experiment, are presented in Tables 54 and 55 and indicate:

- The source of sediments (discharge canal or adjacent estuary) used in recolonization trays did not have a significant effect on macrobenthic community structure (Table 55) and had a significant effect on only 4 out of 22 taxa (Table 54). All taxa showing an effect of

sediment source were more abundant in discharge canal sediments. One was a fouling organism (Polydora sp.), one was an epifaunal organism (Gammarus sp.), one was a relatively rare bivalve (Rangia cuneata), and the final species was Cyathura polita, which had previously demonstrated a preference for discharge canal sediments.

- The experimental location (discharge canal or adjacent estuary) of the recolonization trays did not have a significant effect on macrobenthic community structure (Table 55) but had a significant effect on 9 out of 22 taxa (Table 54). Two of the nine (Nereis succinea and Tendipedidae larvae) were more abundant in recolonization trays located in the discharge canal. The remaining 7 taxa were more abundant in recolonization trays in the adjacent estuary. Both Nereis succinea and Tendipedidae larvae were more abundant in recolonization trays located in the discharge canals during previous months, and 6 of the 7 taxa with higher abundances in estuary sediments had higher abundances in the estuary during previous months.
- No significant interaction terms occurred in the MANOVA (Table 55) and only 2 of 22 taxa had significant interaction terms (Table 54).

Meiobenthos

The results of the recolonization study for the meiobenthic organisms are summarized in Figure 76. Analyses results are summarized in Tables 56 through 65.

Because variances in the densities of the turbellarian of the genus Acoela, harpacticoid copepods, nematodes, and ostracods could not be homogenized, these taxa were not included in the MANOVA analyses for the meiobenthic data. Nonparametric ANOVA were used to analyze the data for these taxa. It should be noted that nematodes numerically dominated meiobenthic community structure on all occasions, and Acoela, ostracods, and harpacticoid copepods were also numerically important components of meiobenthic communities on most sampling dates.

Results of the ANOVA and the MANOVA performed on the meiobenthic data collected over the nine-month study period are presented in Tables 56 and 57. These analyses indicate:

- Sampling month had a significant effect on meiobenthic community structure (Table 57) and on 17 out of 25 meiobenthic taxa (Table 56). Taxa that did not show a significant month effect were generally not abundant (e.g., bivalve larvae) or would generally not be considered benthic although they are occasionally observed in benthic samples (e.g., cladocerans). Most of the variability associated with month can be attributed to reproductive processes.
- The source of sediments (discharge canal or adjacent estuary) used in recolonization trays did not have a significant effect on meiobenthic community structure (Table 57) and had a significant effect for only 2 of 25 meiobenthic taxa (Table 56). Both of the taxa having a significant sediment effect (ciliates and a turbellarian of the genus Acoela) were more abundant in sediments from the adjacent estuary.
- The experimental location (discharge canal or adjacent estuary) of the recolonization trays had a significant effect on meiobenthic community structure (Table 57) and on 13 out of 25 taxa (Table 56). Three of the taxa showing significant location effects were more abundant in the discharge canal (Tendipedidae larvae, Nereis larvae, and tardigrades). Macroinvertebrate insect larvae and Nereis succinea were previously more abundant in recolonization trays located in the discharge canal (see macroinvertebrate section of recolonization study above). The remaining 11 taxa showing significant location effects were more abundant in recolonization trays in the adjacent estuary.
- Interaction terms were frequently significant for the MANOVA and for 10 of 25 taxa for which ANOVA were performed.
- A significant difference among replicates was detected for meiobenthic community structure and for 9 out of 21 taxa for which ANOVAs were performed.

Because of the significant effect of sampling month on meiobenthic recolonization processes, a series of ANOVA and MANOVA were performed on the recolonization data collected one, three, six, and nine months after the start of the experiment. It was anticipated that when the data were analyzed in this manner, the effect of month would be removed and the number of significant interaction terms would be reduced.

Results of the ANOVA and the MANOVA performed on the meiobenthic data collected in October, approximately one month after the start of the recolonization experiment, are presented in Tables 58 and 59. These analyses indicate:

- The source of the sediments (discharge canal or adjacent estuary) used in the recolonization experiment did not have a significant effect on meiobenthic community structure (Table 59) and only had a significant effect on 1 out of 21 taxa (Table 58). The one taxa, ciliates, was more abundant in natural estuarine sediments than in discharge canal sediments.
- The experimental location (discharge canal or adjacent estuary) of the recolonization trays did not have a significant effect on meiobenthic community structure (Table 59) but had a significant effect on 9 out of 21 taxa (Table 58). One of the 9 taxa (Tendipedidae larvae) was more abundant in the recolonization trays in the discharge canal. The remaining 8 taxa were more abundant in trays in the adjacent estuary. Macroinvertebrate insect larvae were also more abundant in the discharge canal.
- Interaction terms were not significant for the MANOVA (Table 59) and only for 1 out of 21 taxa for which ANOVA were performed (Table 58).
- Significant tray effects were detected for only 2 out of 19 taxa in which ANOVA were performed (Table 58). Tray effects were not significant in the MANOVA (Table 59).

Results of the ANOVA and the MANOVA performed on the meiobenthic data collected in December, approximately three months after the start of the experiment, are presented in Tables 60 and 61 and indicate:

- The source of the sediments (discharge canal or adjacent estuary) used in the recolonization experiment did not have a significant effect on meiobenthic community structure (Table 61) and had a significant effect on only 1 out of 13 taxa (Table 60). The one taxa (ciliates) was more abundant in natural estuarine sediments than in discharge canal sediments.
- The experimental location (discharge canal or adjacent estuary) of the recolonization trays had a significant effect on meiobenthic community structure (Table 61) and on 9 out of 13 taxa (Table 60). All 9 of the taxa were more abundant in the estuary than in the discharge canal.
- A significant interaction term occurred only for ciliates (Table 60). Interaction terms in the MANOVA were not significant (Table 61).
- Significant tray effects occurred for meiobenthic community structure (Table 60) and 3 out of 9 taxa (Table 61).

Results of the ANOVA and the MANOVA performed on the meiobenthic data collected in March, approximately six months after the start of the recolonization experiment, are presented in Tables 62 and 63. These analyses indicate:

- The source of the sediments (discharge canal or adjacent estuary) used in the recolonization experiment did not have a significant effect on meiobenthic community structure (Table 63) or for any of the taxa (Table 62).
- The experimental location (discharge canal or adjacent estuary) of the recolonization trays did not have a significant effect on meiobenthic community structure (Table 61) but had a significant effect on 9 out of 16 taxa (Table 62). All of the taxa showing a significant location effect were more abundant in the estuary than they were in the discharge canal.
- Interaction terms in the MANOVA were not significant (Table 63) and only the interaction term for harpacticoid copepods was significant in ANOVA (Table 62).
- A significant community-level tray effect was observed by the MANOVA (Table 63) and a significant tray effect was observed in 5 out of 12 ANOVA (Table 62).

Results of the ANOVA and the MANOVA performed on the meiobenthic data collected in late May, approximately nine months after the start of the recolonization experiment, are presented in Tables 64 and 65. These analyses indicate:

- The source of the sediments (discharge canal or adjacent estuary) did not have a significant effect on meiobenthic community structure (Table 65) and had a significant effect on only 3 out of 17 taxa (Table 64). Two of the three taxa (Tendipedidae larvae and rotifers) were more abundant in the natural estuarine sediments, and the third taxa (nematodes) was more abundant in discharge canal sediments.
- The experimental location (discharge canal or adjacent estuary) of the recolonization trays had a significant effect on meiobenthic community structure (Table 65) and had a significant effect on 10 out of the 17 taxa (Table 64). Four of the 10 taxa showing significant location effects (ciliates, calanoid copepod nauplii, Tendipedidae larvae, and Nereis succinea) were more abundant in recolon-

ization trays in the discharge canal than in trays in the adjacent estuary. The remaining 6 taxa were more abundant in trays in the adjacent estuary. Two of the four taxa that were more abundant in the canal were juveniles of macrobenthic organisms that had previously been observed to be more abundant in the canal environment (*Tendipedidae* larvae and *Nereis succinea*). The remaining two taxa (ciliates and calanoid copepod nauplii) were more abundant in the canal environment in previous months.

- The interaction terms in the MANOVA were not significant (Table 65) and only 3 out of the 17 taxa had significant interaction terms (Table 64).
- The tray effect was not significant for any of the MANOVA (Table 65) but was significant for 3 out of 13 taxa for which parametric ANOVA were performed (Table 64).

Interpretation of Analysis

For the first three sampling periods (October 1979 through March 1980), a significant tray effect was frequently detected for meiobenthic community structure and for many meiobenthic taxa for which parametric ANOVA were performed. This was not unexpected because meiobenthic organisms have extremely heterogeneous distributions within the spatial scales of the recolonization trays. Furthermore, the method of sampling (i.e., removal of trays from the bottom) could add to tray-to-tray variation, resulting in additional error. No matter how carefully trays were handled, surface sediments and meiobenthic organisms would be disturbed. Even with the large error associated with sampling, it was still possible to detect significant differences in the recolonization process of meiobenthic organisms between the discharge canal environment and the estuary. Tray effects were greatly reduced at both the community and taxa level in May, approximately nine months after the start of the experiment (Figure 76). At this point, it appears that surface

sediments had stabilized and the meiobenthic community had reached an equilibrium because taxa and individuals were no longer being added to the trays (Figure 76).

The month when samples were collected had a significant effect on macrobenthic and meiobenthic community structure and most of the taxa and species occurring in the samples. This was because between early September and late May, most of the meiobenthic taxa and macrobenthic species in the Patuxent estuary have some reproductive activity (see previous sections on meiobenthic surveys and monthly sampling program). Most of the meiobenthic taxa that did not show a month effect were juveniles of macrobenthic organisms and were sampled poorly by the survey techniques or were rare organisms with large variation among replicate samples. Most of the macrobenthic species that did not show a month effect were also rare organisms. Based on the data from the recolonization experiment and the two meiobenthic surveys, it appears that meiobenthic recruitment and reproductive activity in the Patuxent occurred mostly in late summer to early fall and late winter to early spring. Macrobenthic reproductive activity appears to occur primarily between early spring and summer.

In general, the source from which sediments were obtained for recolonization trays had very little effect on the recolonization process, and there was no indication of a toxic component in discharge canal sediments. The only infaunal macrobenthic organism whose recolonization process consistently suggested a sediment-source effect was Cyathura polita, a species known to prefer organically enriched sediments in areas where current flow is sufficient to preclude anoxic conditions and which was more abundant in discharge canal

sediments. The only meiobenthic taxa exhibiting a consistent effect due to the source of sediments was the ciliates. These organisms also probably prefer organically enriched habitats.

The recolonization process was slower in the discharge canal environment than in the adjacent estuary. Location had a significant effect on most species during most sampling periods. The majority of the taxa (~88%) were less abundant in the discharge canal than in the adjacent estuary. The only taxa showing a consistent preference for the canal environment were Nereis succinea (adults and juveniles), Tendipedidae larvae, and Limnodrilus hoffmeisteri (adults and juveniles). These taxa can tolerate a wide range of environmental conditions and are generally considered to be opportunistic organisms. Nereis succinea is one of the first macrobenthic species to recolonize mud sediments of the main stem of Chesapeake Bay in fall following summertime anoxic conditions (Holland et al. 1977). Limnodrilus hoffmeisteri is an oligochaete previously shown (Holland et al. 1980a) to favor environments near the discharge point, even though this site was not in its preferred salinity zone. Tendipedidae larvae have not previously been shown to prefer the nearfield or canal environment. However, they could have easily been washed into the canal from the freshwater holding ponds adjacent to the canal.

The relatively small number of significant interaction terms indicated that recolonization experiments were conducted in a reasonable manner and with an acceptable level of unexplainable variation.

Should benthic recolonization experiments be conducted at other power plants, the following changes in experimental design are suggested:

- At least two or three reference areas upstream and downstream of the discharge site should be selected. This would allow an accounting for the effects of salinity and other factors varying along the estuarine gradient.
- Both nearfield and farfield stations should be used. This would allow for rigorous determination of the effects of the plant.
- Recolonization trays (at one return site and one affected site) should be sampled frequently for the first month. We suggest after 1, 3, 6, 12, 24, and 30 days. Sampling at this frequency would provide basic information about the rate of recolonization during the first 30 days, which was not obtained from this study.
- Recolonization trays at selected reference and affected areas should be monitored on a schedule (probably quarterly) that allows the investigator to determine when the rate of recolonization becomes asymptotic (i.e., no new species are added and numeric dominants have stabilized). At this point, the experimental tray should be collected and processed.
- MANOVA, ANOVA, and ACOVA are all suitable analysis techniques and should be used in conjunction with one another for analysis of the recolonization data collected at the equilibrium point.

e. Organic Enrichment Experiment

Organic enrichment from entrainment-killed plankton settling to the bottom has been suggested as a factor contributing to higher standing stocks of deposit feeding benthic organisms near some power plant discharges (Holland et al. 1978). To determine whether Patuxent benthic populations respond to low levels of organic enrichment, a field experiment was conducted near the Chalk Point SES between 1979 and 1980. To prevent bottom feeding predators from interfering with experimental results, they were excluded from the organically enriched site by cages. The enrichment material was Milorganite®, an organic fertilizer made from sewage, and was introduced biweekly.

The abundance data collected at the organically enriched site are summarized in Table 66, and the sediment data from the organically enriched site are presented in Table 28. Milorganite® pellets were frequently observed

in sediments collected at the enriched site. The abundance data collected from the adjacent uncaged reference area and from inside a control cage (both areas were not organically enriched) are summarized in Tables 29 and 30.

Results of the MANOVA's and ANOVA's testing for station effects in the abundance data collected at the caged and organically enriched site and in the adjacent uncaged reference area at the start of the experiment are presented in Tables 67 through 68. The results of similar testing for station effects between the caged and organically enriched area and the adjacent control cage that was not organically enriched are summarized in Tables 69 and 70. There were no significant differences in the macrobenthic community structure among the sites at the start (September) of the experiment (Tables 68 and 70) or for any of the taxa for which ANOVA's were accomplished (Tables 67 and 69). Thus, at the beginning of the experiment, all the experimental sites were similar.

Results of the ANOVA's and MANOVA's comparing the data collected at the organically enriched test site to that at the uncaged reference area and the control cage from September 1979 through May 1980 are presented in Tables 71 through 74. These analyses indicate:

- Organic enrichment had a significant effect (i.e., station differences) on macrobenthic community structure (Table 72) and on abundance of 5 of 13 taxa (Tables 71). Taxa showing significant station effects (Corophium sp., Hypaniola grayi, Macoma phenax, Scolecoides viridis, Tenebrionidae larvae) showed station effects during predator exclusion experiments that were attributed to the effects of caging on sedimentation inside the caged area (i.e., organic enrichment).
- No significant station differences were detected in the MANOVA comparing macrobenthic community structure between the organically enriched and caged site to the control cage (Table 74). None of the 13 taxa on which ANOVA's were accomplished showed significant station differences in abundance between these experimental sites (Table 73).

- A significant month effect occurred in the MANOVA comparing the organically enriched caged area to the uncaged reference area (Table 72), and in the MANOVA comparing the organically enriched site to the control cage (Table 74). Significant month effects were also detected for 8 of 13 taxa (Tables 71 and 73). The effect of sampling month on abundances was attributable to reproductive activity of the species composing Patuxent benthic communities.
- A significant interaction term occurred in the MANOVA comparing macrobenthic community structure at the organically enriched and caged site and the uncaged reference site (Table 72) and for 3 of 13 taxa (Table 71). The interaction term (month x station) was not significant in the MANOVA comparing macrobenthic community structure between the organically enriched area and the control cage (Table 74). A significant interaction term did occur for 1 of 13 taxa, Tendipedidae larvae (Table 73).

Because of the effect that sampling month had on the organic enrichment experiment, a series of ANOVA's and MANOVA's were accomplished on the data collected at the start (September) of the experiment and at approximately one (October), six (March), and nine (May) months after the start of the experiment. It was anticipated that sequential analysis would remove the month effect but still allow temporal patterns of trends to be described and characterized.

Results of the experiment comparing the data collected over the nine-month period are presented in Tables 66 through 70 and indicate:

- Organic enrichment did not have a significant effect (i.e., station effect) on macrobenthic community structure (Table 68) or on abundance of any of the 13 taxa in October (Table 66). One species (Scolecopides viridis) was significantly more abundant in the control cage than it was at the reference site or in the organically enriched cage in October (Table 69). The higher S. viridis abundances in the control cage caused the macrobenthic community structure at the uncaged reference area and in the organically enriched cage to be significantly different from that in the control cage (Table 69).
- Organic enrichment did not have a significant effect on macrobenthic community structure in March (Table 68), and only 1 of the 13 taxa (Corophium sp.) showed a significant effect from organic enrichment (Table 67). Corophium sp. was significantly more abundant at the organically enriched site than it was at the reference area or the control cage.

- In May, macrobenthic community structure at the organically enriched site was significantly different from that in the reference area (Table 68) but not significantly different from the control cage (Table 70). Significant station effects were detected in the abundance of 5 of 13 taxa for which ANOVA's compared the organically enriched site to the adjacent control area. Two of the species (Macoma balthica and Nereis succinea) were more abundant in the uncaged control area. The other three (Hypaniola grayi, Tendipedidae larvae, and Tubificodes heterochaetus) were deposit feeders and were more abundant inside the enriched cage. Two of 13 taxa for which ANOVA's compared the organically enriched site to the control cage showed significant differences in abundance between locations in May (Table 68). These (Nereis succinea and Tubificodes heterochaetus) were significantly less abundant at the organically enriched site than inside the control cage.

In summary, these analyses show that the response of benthic organisms to organic enrichment was small but significant, and primarily involved deposit feeding infaunal species having adaptations that allow them to use any increased enrichment. Some of the species had higher standing stocks in the discharge region of the plant. Few station differences were detected by comparison of the organically enriched caged area to the unenriched site where predators were excluded. Based on the findings of the organic enrichment experiment, it appears that some benthic organisms (i.e., deposit feeders) can respond to the kind of organic enrichment that results from power plant operations, by increasing their stock size.

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VII. TABLES

Table 1. Modes of interaction between benthic organisms and the Chalk Point power plant and possible consequences of interactions.

Life Stage	Direct Interaction	Type of Stress	Possible Consequence to Organism	Possible Consequence to Population
Eggs and larvae	Entrainment (passage through cooling system)	Mechanical and physiological	Mortality, physiological or morphological impairment (e.g., greater vulnerability to predation), and redistribution (species are taken from downstream areas and redistributed to upstream areas that have lower salinities)	Increase or decrease in the number and types of eggs or larvae settling in the nearfield region (dependent upon localization of spawning and number of larvae in intake waters), which could affect the structure of benthic communities at the discharge site
	Exposure to elevated temperatures and toxic chemicals during transit down the discharge canal	Physiological	Mortality and physiological impairment	Increase or decrease in the number and types of larvae settling in the nearfield region, which could affect the structure of benthic communities at the discharge site
	Augmentation pump entrainment (passage through augmentation pumps)	Mechanical and physiological	Mortality, physiological or morphological impairment, and redistribution	Increase or decrease in the number and types of larvae settling in the nearfield region, which could affect the structure of benthic communities at the discharge site
	Plume entrainment (mixing with discharge waters)	Physiological	Mortality and physiological impairment (e.g., exposure to high levels of copper or oxidant residuals in discharge region)	Increase or decrease the number of eggs or larvae settling in the nearfield region (dependent upon localization of spawning and the number of larvae subjected to plume entrainment), which could affect the structure of benthic communities at the discharge site
Juveniles and adults	Entrainment of motile species by intake and augmentation pumps	Mechanical and physiological	Mortality, abrasion (e.g., loss of appendages), physiological impairment (e.g., weakened organism not able to withstand natural stresses of estuarine environment), and redistribution	Increase or decrease in local populations (dependent on population distributions), which could affect the structure of benthic communities at the discharge site

Table 1. Continued.

Life Stage	Direct Interaction	Type of Stress	Possible Consequence to Organism	Possible Consequence to Population
Juveniles and adults (cont.)	Impingement on intake screens	Mechanical and physiological	Mortality, abrasion (e.g., loss of appendages), and physiological impairment (e.g., weakened organism not able to withstand natural stresses of estuarine environment when returned to the receiving body)	Increase or decrease in local populations (dependent on population distributions), which could affect the structure of benthic communities at the discharge site
	Exposure to elevated temperatures and toxic chemicals in the discharge canal and thermal plume	Mechanical and physiological	Mortality, abrasion, and change in physiological condition (e.g., change in the timing of reproduction of organisms in the plume area)	Increase or decrease in local stocks, which could affect the structure of benthic communities at the discharge site
	Exposure to organic enrichment resulting from plant-related entrainment mortalities	Changes in sediment characteristics and type of food available in nearfield area	Change in the number, kinds, and growth rates of some species in the discharge area	Increase or decrease in local stocks, which could affect the structure of benthic communities at the discharge site
	Exposure to enriched levels of heavy metals from corrosion of condenser tubes	Physiological	Mortality and change in physiological condition	Change in the physiological condition and/or abundance of local stocks in the affected region. At high levels of metal enrichment, commercially harvested species may become unfit for human consumption because of bitter taste and green coloration

Table 2. Sampling design and history of benthic studies that were conducted at the Chalk Point power plant by EC and CBL for the PPSP.

Study	Parameters Measured	Sampling Method	Sampling Location	Number of Replicate Samples	Sampling Frequency	Period of Data Collection
Macrobenthic estuary-wide surveys	Density and biomass of macrobenthic organisms; population characteristics of <i>Macoma balthica</i> ; sediment characteristics, salinity, temperature, and dissolved oxygen levels	Samples collected with a hydraulic grab (0.12-m ²) or box corer (0.02-m ²) and sieved through a 0.5-mm screen	Stations 1-12	3-4	Once	April 1978
			Stations 1-12	3-4	Once	October 1978
			Stations 1-12, 22, 25-28, and 41-43	3-4	Once	September 1979
Meiobenthic comprehensive surveys	Density of meiobenthic taxa; sediment characteristics, salinity, temperature, and dissolved oxygen levels	Samples (10-cm ²) collected from box corer and sieved through a 63-µm screen	Stations 3, 5, 41, 8, 9, and 10	3	Twice	July 1979 and January 1980
Microbenthic comprehensive surveys	ATP; sediment characteristics, salinity, temperature, and dissolved oxygen levels	Approximately 1-cm ² samples collected from box corer	Stations 3, 5, 41, 8, 9, and 10	5	Once	July 1979
Nearfield macrobenthic surveys	Density and biomass of macrobenthic organisms; population characteristics of <i>Macoma balthica</i> ; sediment characteristics, salinity, temperature, and dissolved oxygen levels	Samples collected with a hydraulic grab (0.12-m) and sieved through a 0.5-mm screen	Stations 5, 6, 7, and 8	4	Monthly	April 1978 - May 1979
		Samples collected with a box corer (0.02-m ²) and sieved through a 0.5-mm screen	Stations 3, 5, 41, 8, 9, and 10	4	Bimonthly	July 1979 - July 1980

Table 2. Continued

Study	Parameters Measured	Sampling Method	Sampling Location	Number of Replicate Samples	Sampling Frequency	Period of Data Collection
Discharge canal macrobenthic surveys	Density and biomass of macrobenthic organisms; sediment characteristics, salinity, temperature, and dissolved oxygen levels	Samples collected with a hydraulic grab (0.12-m ²) and sieved through a 0.5-mm screen	Stations 13, 14, 15	3	Monthly	July 1978 - June 1979
Predator exclusion experiments	Density of macrobenthic organisms; sediment characteristics, salinity, and dissolved oxygen levels	Samples collected with a box corer (0.02-m ²) and sieved through a 0.5-mm screen	Discharge region and Teague Point	6	Monthly	April 1978 - August 1978
Recolonization experiment	Density of macrobenthic and meiobenthic organisms in recolonizing trays containing azoic discharge canal and natural Patuxent estuary sediments	Cores (10-cm ²) of recolonization trays for meiobenthic organisms, remainder of 625 cm ² recolonization trays was sieved through a 0.5-mm screen	Discharge canal and reference area	3	1, 3, 6, and 9 months after start of experiment	September 1979 - September 1980
Organic enrichment experiment	Density of macrobenthic organisms; sediment characteristics	Samples collected with a box corer (0.02-m ²) and sieved through a 0.5-mm screen	Nearshore site at Station 5	3	1, 3, 6, and 9 months after start of experiment	July 1979 - July 1980
Population studies of <i>Macoma balthica</i>	Density, biomass, age class structure, growth, and mortality of <i>M. balthica</i>	Samples collected with a hydraulic grab (0.12-m ²) and sieved through a 0.5-mm screen	Stations 5, 6, 7, and 8	4	Monthly	April 1978 - July 1979
			Stations 1-12	3-4	Twice	April 1978 and October 1978
			Stations 3, 5, 41, 8, 9, and 10	4	Bimonthly	July 1979 - July 1980
			Stations 1-12, 22, 25-28, and 41-43	3-4	Once	September 1979

Table 3. Summary of rainfall and its deviation from normal for the Patuxent watershed from 1978 through 1980*

Month	Normal Rainfall	Actual Rainfall	Departure from Normal
January 1978	7.39	18.64	+11.25
February	7.14	1.42	- 5.12
March	9.37	12.04	+ 2.67
April	7.80	3.20	- 4.60
May	9.17	13.94	+ 4.77
June	9.58	7.14	- 2.44
July	10.34	17.35	+ 7.01
August	10.69	8.61	- 2.08
September	7.92	2.62	- 5.30
October	7.14	1.80	- 5.34
November	7.95	6.86	- 1.09
December	8.28	11.76	+ 3.48
January 1979	7.39	19.91	+12.52
February	7.14	18.19	+11.05
March	9.37	5.21	- 4.16
April	7.80	8.56	+ 0.76
May	9.17	10.54	+ 1.37
June	9.58	14.50	+ 5.00
July	10.34	9.42	- 0.92
August	10.69	23.83	+13.14
September	7.92	17.09	+ 9.17
October	7.14	14.05	+ 6.91
November	7.95	6.22	- 1.73
December	8.28	2.21	- 6.07
January 1980	7.39	6.55	- 0.84
February	7.14	10.77	+ 3.63
March	9.37	13.87	+ 4.50
April	7.80	2.69	- 5.11
May	9.17	6.55	- 2.62

* Data from National Oceanographic and Atmospheric Administration annual summaries for Baltimore/Washington International Airport.

Table 4. Relationships among the physical data collected along the Patuxent estuarine-gradient during the comprehensive survey in September 1979*

	Salinity (ppt)	Interstitial Salinity (ppt)	Temperature (°C)	Dissolved Oxygen (ppm)	Moisture Content (%)	Silt-Clay Content (%)	Total Carbon Content (%)	Available Carbon Content (%)
Salinity (ppt)		0.85	0.63	-0.24	-0.66	-0.87	-0.81	-0.76
Interstitial Salinity (ppt)	0.10		0.78	-0.30	-0.55	-0.76	-0.81	-0.72
Temperature (°C)	-0.09	0.42		-0.05	-0.13	-0.45	-0.48	-0.38
Dissolved Oxygen (ppm)	-0.10	-0.22	0.59*		0.13	0.07	0.44	0.13
Moisture Content (%)	0.41	0.16	0.65**	-0.32		0.89	0.84	0.91
Silt-Clay Content (%)	-0.69**	-0.23	-0.30	-0.08	0.74**		0.85	0.90
Total Carbon Content (%)	-0.20	-0.11	-0.60**	0.76**	0.65**	-0.31		0.90
Available Carbon Content (%)	0.01	-0.18	0.15	-0.45*	0.13	0.03	0.46*	

* Values above the 45 degree diagonal are correlation coefficients. Values below the 45 degree diagonal are partial correlation coefficients. Asterisks indicate partial correlations that are significantly ($P < 0.05$) different from zero. The number of observations was 20.

Table 5. Summary of benthic species diversity data for sample sites in the Patuxent estuary between Broomes Island and the Western Branch*

Sample Site (Station)	Shannon's Index (H')			Maximum Diversity (H'_{\max})		
	$H' = -\sum p_j \ln p_j$			$H'_{\max} = \ln s$		
	Normal Spring (high flow)	Normal Fall (low flow)	Wet Fall (high flow)	Normal Spring (high flow)	Normal Fall (low flow)	Wet Fall (high flow)
1	1.94	1.37	1.79	2.58	2.26	2.42
2	1.57	1.68	1.59	2.48	2.65	1.83
3	1.91	1.42	1.84	2.61	2.46	2.30
4	1.94	1.46	1.85	2.58	2.39	2.36
5	1.50	1.43	1.10	2.82	2.59	1.94
6	1.67	1.69	1.87	2.58	2.60	2.16
41	-	-	1.35	-	-	1.97
7	0.97	1.81	0.86	2.18	2.67	1.60
8	0.88	0.59	0.72	2.62	2.76	1.90
9	1.00	0.79	0.82	2.37	2.83	1.60
10	0.89	1.06	1.55	2.18	2.39	1.70
11	0.88	1.39	1.24	1.60	2.45	1.24
12	0.80	1.86	0.48	1.60	2.65	0.92
22	-	-	0.33	-	-	1.30

p = proportional abundance of the j th species in a sample

s = number of species present

* = Data for stations receiving maximum excess temperatures are outlined. Dash indicates station was not sampled in time periods.

Table 5. Continued

Sample Site (Station)	Evenness (J) $J = \frac{H'}{\ln s}$			Hills Ratio (E) $E = \ln \frac{\exp H'}{s}$		
	Normal Spring (high flow)	Normal Fall (low flow)	Wet Fall (high flow)	Normal Spring (high flow)	Normal Fall (low flow)	Wet Fall (high flow)
1	0.72	0.61	0.74	0.49	0.42	0.54
2	0.64	0.64	0.87	0.42	0.38	0.79
3	0.73	0.58	0.80	0.50	0.36	0.64
4	0.75	0.60	0.78	0.53	0.39	0.60
5	0.62	0.55	0.60	0.34	0.32	0.49
6	0.65	0.65	0.87	0.41	0.41	0.75
41	-	-	0.69	-	-	0.56
7	0.46	0.68	0.56	0.33	0.42	0.49
8	0.34	0.21	0.38	0.18	0.12	0.31
9	0.42	0.27	0.52	0.34	0.13	0.47
10	0.41	0.45	0.91	0.34	0.27	0.87
11	0.56	0.57	1.00	0.49	0.35	1.00
12	0.50	0.71	0.48	0.45	0.46	0.64
22	-	-	0.25	-	-	0.40

Table 6. Summary of the proportion of the spatial variation in standing stock size of the eurytolerant marine species that can be explained by the physical/chemical factors monitored

Species-Date	Water Column Characteristics			Sediment Characteristics				Silt-Clay Content (%)	Total Variance Explained by Regression (r ²)
	Salinity (ppt)	Temperature (°C)	Dissolved Oxygen (ppm)	Interstitial Salinity (ppt)	Moisture Content (%)	Available Carbon Content (%)	Total Carbon Content (%)		
<u>Heteromastus filiformis.</u>									
April 1978	0.89			0.06					0.95
October 1978			0.81			0.06			0.86
September 1979	0.75	0.03						0.05	0.83
<u>Nereis succinea</u>									
April 1978	0.84					0.06			0.90
October 1978				0.88				0.03	0.91
September 1979	0.47								
<u>Macoma phenax</u>									
April 1978	0.82			0.06					0.88
October 1978		0.14							0.14
September	0.43								0.43
<u>Streblospio benedicti</u>									
April 1978		0.31					0.16	0.14	0.61
October 1978*	No relationship detected between the physical/chemical factors monitored and density of standing stocks on this date.								
September 1977					0.79			0.19	0.97

* The estuarine-wide distribution of this species is shown in Figure 33.

Table 7. Model statistics derived from stepwise linear regression to the eurytolerant marine species*

Species	April 1978	October 1978	September 1979
<u>Heteromastus filiformis</u>	$\alpha = -0.68056$ $\beta_1(\text{salinity}) = 0.48995 \pm 0.07702$ $\beta_2(\text{interstitial salinity}) = 0.46769 \pm 0.07855$	$\alpha = 18.88374$ $\beta_1(\text{dissolved oxygen}) = -1.28781 \pm 0.17093$ $\beta_2(\text{available carbon content}) = -130.42743 \pm 41.49363$	$\alpha = -10.34814$ $\beta_1(\text{temperature}) = 0.73763 \pm 0.32705$ $\beta_2(\text{interstitial salinity}) = 0.36676 \pm 0.19134$ $\beta_3(\text{silt-clay content}) = -3.20901 \pm 1.04261$
<u>Nereis succinea</u>	$\alpha = -6.17424$ $\beta_1(\text{salinity}) = 1.16248 \pm 0.11169$ $\beta_2(\text{available carbon content}) = 182.01339 \pm 47.91301$	$\alpha = 0.37059$ $\beta_1(\text{interstitial salinity}) = 0.51865 \pm 0.03455$ $\beta_2(\text{silt-clay content}) = -3.08372 \pm 1.12596$	$\alpha = -0.45340$ $\beta_1(\text{salinity}) = 0.51754 \pm 0.09538$
<u>Macoma phenax</u>	$\alpha = -0.40362$ $\beta_1(\text{salinity}) = 0.33667$ $\beta_2(\text{interstitial salinity}) = 0.33009$	$\alpha = -8.01027$ $\beta_1(\text{temperature}) = 0.80336 \pm 0.38335$	$\alpha = -0.55642$ $\beta_1(\text{salinity}) = 0.74646 \pm 0.21999$
<u>Streblospio benedicti</u>	$\alpha = 23.20465$ $\beta_1(\text{temperature}) = -1.85005 \pm 0.81363$ $\beta_2(\text{total carbon content}) = -72.14710 \pm 22.56773$ $\beta_3(\text{silt content}) = 11.07527 \pm 2.57356$		$\alpha = 6.30084$ $\beta_1(\text{available carbon content}) = -809.80713 \pm 54.33636$ $\beta_2(\text{silt-clay content}) = 13.40271 \pm 1.42337$

*The general model is $\ln(\hat{Y}) = \alpha + \beta_1(\text{measured value of physical/chemical factor}) + \beta_2(\text{measured value of physical/chemical factor})$ where $\ln(\hat{Y})$ is the natural logarithm of predicated density of standing stock size. Confidence limits indicated for the β 's are \pm one standard error. Dashes indicate that no relationship was detected between the physical/chemical factors monitored and standing stock size.

Table 8. Summary of the proportion of the spatial variation in standing stock size of the estuarine species that can be explained by the physical/chemical factors monitored

Species-Date	Water Column Characteristics			Sediment Characteristics					Total Variance Explained by Regression (r^2)
	Salinity (ppt)	Temperature (°C)	Dissolved Oxygen (ppm)	Interstitial Salinity (ppt)	Moisture Content (%)	Available Carbon Content (%)	Total Carbon Content (%)	Silt-Clay Content (%)	
<u>Cyathura polita</u>									
April 1978					0.36			0.22	0.58
October 1978			0.22	0.12					0.40
September 1979	0.16	0.47			0.14			0.10	0.87
<u>Leptocheirus plumulosus</u>									
April 1978	0.84			0.05					0.89
October 1978	0.34		0.29						0.61
September 1979	No relationship detected between the physical/chemical factors monitored and density of standing stocks on this date.								
<u>Macoma balthica</u>									
April 1978	0.88			0.06					0.94
October 1978	0.90								0.90
September 1979			0.05	0.60			0.13		0.78
<u>Scolecoplepides viridis</u>									
April 1978					0.52				0.52
October 1978	No relationship detected between the physical/chemical factors monitored and density of standing stocks on this date.								
September 1979	0.13			0.05		0.52			0.69

Table 8. Continued

Species-Date	Water Column Characteristics			Sediment Characteristics					Total Variance Explained by Regression (r^2)
	Salinity (ppt)	Temperature (°C)	Dissolved Oxygen (ppm)	Interstitial Salinity (ppt)	Moisture Content (%)	Available Carbon Content (%)	Total Carbon Content (%)	Silt/Clay Content (%)	
<u>Tubificoides heterochaetus</u>									
April 1978									No relationship detected between the physical/chemical factors monitored and density of standing stocks on this date.
October 1979									No relationship detected between the physical/chemical factors monitored and density of standing stocks on this date.
September 1979		0.63	0.13						0.76
<u>Unidentified nemertean</u>									
April 1978				0.66					0.66
October 1978		0.39							0.39
September 1979				0.54					0.54

Table 9. Model statistics derived from stepwise linear regression for the estuarine species

Species	April 1978	October 1978	September 1979
<u>Cyathura polita</u>	$\alpha = 8.07244$ $\beta_1(\text{moisture content}) = -25.65852 \pm 4.33329$ $\beta_2(\text{silt content}) = 11.55763 \pm 3.17276$	$\alpha = 25.67827$ $\beta_1(\text{dissolved oxygen}) = -1.74766 \pm 0.43670$ $\beta_2(\text{interstitial salinity}) = 0.44454 \pm 0.15797$	$\alpha = -56.00362$ $\beta_1(\text{temperature}) = 3.62664 \pm 0.29356$ $\beta_1(\text{salinity}) = -0.25034 \pm 0.04353$ $\beta_2(\text{moisture content}) = -71.12957 \pm 9.67682$ $\beta_4(\text{silt-clay content}) = 38.31706 \pm 4.74945$
<u>Leptocheirus plumulosus</u>	$\alpha = 0.29715$ $\beta_1(\text{salinity}) = 0.44773 \pm 0.10635$ $\beta_2(\text{interstitial salinity}) = 0.39012 \pm 0.10847$	$\alpha = -20.85098$ $\beta_1(\text{salinity}) = 0.52974 \pm 0.15423$ $\beta_2(\text{dissolved oxygen}) = 2.00700 \pm 0.48725$	-
<u>Macoma balthica</u>	$\alpha = 0.38220$ $\beta_1(\text{salinity}) = 0.55343 \pm 0.10175$ $\beta_2(\text{interstitial salinity}) = 0.48454 \pm 0.10377$	$\alpha = -1.95829$ $\beta_1(\text{salinity}) = 0.63256 \pm 0.04021$	$\alpha = 3.19656$ $\beta_1(\text{dissolved oxygen}) = -0.93477$ $\beta_2(\text{interstitial salinity}) = 1.19333 \pm 0.17852$ $\beta_3(\text{total carbon content}) = 32.66305 \pm 10.44977$
<u>Scolecoplepides viridis</u>	$\alpha = -1.67771$ $\beta_1(\text{moisture content}) = 11.44803 \pm 2.09915$	-	$\alpha = 9.29779$ $\beta_1(\text{salinity}) = -0.09482 \pm 0.02397$ $\beta_2(\text{interstitial salinity}) = -0.33215 \pm 0.15622$ $\beta_3(\text{available carbon content}) = -283.61101 \pm 43.42399$

* The general model is $\ln(\hat{Y}) = \alpha + \beta_1(\text{measured value of physical/chemical factor}) + \beta_2(\text{measured value of physical/chemical factor})$ where $\ln(\hat{Y})$ is the natural logarithm of the predicted density of standing stock size. Confidence limits indicated for the β 's are \pm one standard error. Dashes indicate that no relationship was detected for the physical/chemical factors monitored and standing stock size.

Table 9. Continued

Species	April 1978	October 1979	September 1978
<u>Tubificodes heterochaetus</u>	-	-	$\alpha = -17.57973$ $\beta_1(\text{temperature}) = 1.47037 \pm 0.19405$ $\beta_2(\text{dissolved oxygen}) = -1.17732 \pm 0.30158$
Unidentified nemerteans	$\alpha = 0.56844$ $\beta_1(\text{interstitial salinity}) = 0.47563 \pm 0.06578$	$\alpha = -18.86460$ $\beta_1(\text{temperature}) = 1.44814 \pm 0.34949$	$\alpha = -0.27935$ $\beta_1(\text{interstitial salinity}) = 0.62927 \pm 0.10658$

Table 10. Mean size (shell-length in mm) of each age class of Macoma balthica at each station during the comprehensive surveys*

Station	YEARCLASS BY SAMPLING DATE						
	1979	1978			1977		
	September 1979	April 1978	October 1978	September 1979	April 1978	October 1978	September 1979
1	9.0	2.7	10.9	-	14.5	17.5	-
2	-	2.7	10.6	-	14.2	18.5	25.5
3	9.5	1.9	12.4	17.1	13.9	19.6	20.4
4	12.3	1.5	12.7	16.7	13.0	19.0	22.5
5	10.9	1.3	12.7	17.6	13.0	18.3	21.6
6	9.7	1.5	11.6	-	13.6	18.8	22.8
41	11.6			17.0			23.0
26	12.5			18.5			23.8
7	11.7	1.2	13.7	-	19.3	22.6	25.2
8	14.4	1.2	13.9	-	17.4	22.0	25.8
9	11.0	1.0	-	-	19.2	-	23.5
27	-			-			24.6
10	-	-	-	-	22.0	26.0	-
11	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-
22	-			-			-

*Blanks indicate station was not sampled. Dashes indicate M. balthica did not occur in samples that were collected. Data for stations receiving maximum excess temperatures are outlined.

Table 10. Continued

Station	YEARCLASS BY SAMPLING DATE					
	1976			Older		
	April 1978	October 1978	September 1979	April 1978	October 1978	September 1979
1	19.9	21.4	-	28.7	29.4	-
2	19.8	24.5	-	25.9	27.4	-
3	21.8	23.7	25.0	27.8	28.1	-
4	23.0	23.9	27.0	29.7	28.4	-
5	21.5	24.3	25.3	29.3	28.9	29.0
6	22.9	23.9	-	30.9	28.6	30.3
41			-			29.0
26			-			30.0
7	-	-	-	32.1	33.7	-
8	27.2	28.1	-	32.7	31.8	34.0
9	25.0	23.5	-	31.8	33.7	31.0
27			-			36.0
10	-	-	-	-	-	-
11	-	-	-	-	-	-
12	-	-	-	-	-	-
22			-			-

Table 11. Growth rates (K), asymptotic size (L_{∞}), and mortality rates (M) for Macoma balthica in the Patuxent estuary

Decreasing salinity ↓	Station	K	L_{∞}	M
	1	0.415	32.73	1.77
	2	0.489	30.65	1.29
	3	0.461	33.30	1.48
	4	0.461	33.70	1.18
	5	0.366	35.60	2.12
	6	0.379	36.63	1.64
	7	0.589	34.69	1.37
	8	0.564	35.34	1.20

Table 12. Comparison of growth rates (K) and asymptotic size (L_{∞}) of Macoma balthica for ten geographic regions

Location	K	L_{∞} (mm)
Patuxent River (mean)	0.4651 ± 0.081	34.1
Rand Harbor, Buzzards Bay, Massachusetts (Gilbert 1973)	0.4362 ± 0.078	26.0
Wadden Zee, Den Helder, Netherlands (Lammens 1967)	0.3532 ± 0.017	23.0
North Sea, Germany (Vogel 1949)	0.3550 ± 0.051	22.0
Hudson's Bay, Churchill, Manitoba (Green 1973)	0.3831 ± 0.054	17.0
Gulf of Finland, Tvarminne, Finland (Segerstrale 1960)	0.0647 ± 0.023	18.4
St. Laurence River, Cacouna, Quebec (Lavoie et al. 1968)	0.1892 ± 0.032	13.0
Kandalski Bay, White Sea, USSR (Semenova 1970)	0.0523 ± 0.023	17.0

Table 12. Continued

Location	K	L ∞ (mm)
Windsor Flat, Bay of Fundy, Canada (Turk et al. 1980)	0.253	21.9
Mungo Brook, Bay of Fundy, Canada (Turk et al. 1980)	0.204	21.9

Table 13. Summary of the proportion of the spatial variations in standing stock size of freshwater species explained by the physical/chemical factors monitored


Species-Date	Water Column Characteristics			Sediment Characteristics					Total Variance Explained by Regression (r ²)
	Salinity (ppt)	Temperature (°C)	Dissolved Oxygen (ppm)	Interstitial Salinity (ppt)	Moisture Content (%)	Available Carbon Content (%)	Total Carbon Content (%)	Silt-Clay Content (%)	
<u>Gammarus</u> species									
April 1978	No relationship detected between physical/chemical factors monitored and density of standing stocks on this date.								0.40
October 1978				0.40					0.33
September 1979	0.33								
<u>Limnodrilus hoffmeisteri</u>									
April 1978	No relationship detected between physical/chemical factors monitored and density of standing stocks on this date.								0.42
October 1978	0.29		0.13						0.73
September 1979		0.32	0.41						
Tendipedidae larvae									
April 1978	0.56								0.56
October 1978	0.87								0.87
September 1979	0.22			0.33					0.55

Table 14. Model statistics derived from stepwise linear regression for the freshwater species

Species	April	October 1978	September 1979
<u>Gammarus</u> species	-	$\alpha = 4.49418$ $\beta_1(\text{interstitial salinity}) = -0.30480 \pm 0.07196$	$\alpha = 1.92829$ $\beta_1(\text{interstitial salinity}) = -0.25827 \pm 0.07053$
<u>Limnodrilus hoffmeisteri</u>	-	$\alpha = 19.59572$ $\beta_1(\text{salinity}) = 0.52825 \pm 0.14097$ $\beta_2(\text{dissolved oxygen}) = -1.06936 \pm 0.44536$	$\alpha = 50.81888$ $\beta_1(\text{temperature}) = -1.54467 \pm 0.21735$ $\beta_2(\text{dissolved oxygen}) = -2.23103 \pm 0.33779$
Tendipedidae larvae	$\alpha = 2.61967$ $\beta_1(\text{salinity}) = -0.39943 \pm 0.06861$	$\alpha = 6.58031$ $\beta_1(\text{salinity}) = -0.44583 \pm 0.03321$	$\alpha = 3.52038$ $\beta_1(\text{salinity}) = 0.06907 \pm 0.01860$ $\beta_2(\text{interstitial salinity}) = -0.47956 \pm 0.09292$

* The general model is $\ln(\hat{Y}) = \alpha + \beta_1 (\text{measured value of physical/chemical factor}) + \beta_2 (\text{measured value of physical/chemical factor})$ where $\ln(\hat{Y})$ is the natural logarithm of the predicted density of standing stock size. Confidence limits indicated for the β 's are \pm one standard error. Dashes indicate that no relationship was detected between the physical/chemical factors monitored and standing stock size.

Table 15. Summary of meiobenthic data (numbers per m²) collected along the estuarine gradient during July 1979*

Taxon	Station					
	3	5	41	8	9	10
Total meiofauna	125,650	101,309	58,549	118,413	131,897	24,999
Nematodes	108,871 (87)	69,074 (68)	38,159 (65)	34,211 (29)	73,682 (56)	18,087 (72)
Oligochaetes	13,814 (11)	28,942 (29)	17,761 (30)	74,334 (63)	51,312 (39)	2,299 (9)
Other (e.g., harpacticoid, copepods, foraminiferans, ostracods)	2,965 (2)	3,293 (3)	2,628 (5)	9,867 (8)	6,904 (5)	4,612 (19)
 Increasing Salinity						

*The numbers in parentheses are the percentage of total meiobenthic standing stock accounted for by particular taxa.


Table 16. Summary of meiobenthos data (numbers per m²) collected in Osborn Cove in July 1979*

Sediment Classification	Taxon				
	Total	Nematodes	Turbellarians	Oligochaetes	Copepods
Sand	1,720,341	1,518,917(88)	59,213(3)	6,580(<1)	3,290(<1)
Muddy-Sand	1,296,424	1,096,064(85)	8,390(<1)	12,831(1)	2,961(<1)
Mud	1,659,147	1,403,383(85)	4,934(<1)	-	2,460(<1)

Sediment Classification	Taxon				
	Gastrotrichs	Ostrachods	Foraminiferans	Ciliates	Polychaetes
Sand	34,215(2)	6,908(<1)	44,080(3)	25,611(2)	11,514(<1)
Muddy-Sand	-	13,818(1)	-	-	-
Mud	-	-	1,480(<1)	4,442(<1)	-

*The numbers in parentheses are the percentage of total meiobenthic standing stock accounted for by particular taxa.

Table 17. Summary of meiofaunal data (numbers per m²) collected along the Patuxent estuarine gradient during January 1980*

Taxon	Station					
	3	5	41	8	9	10
Total meiofauna	893,027	981,178	374,973	512,134	461,808	725,276
Nematodes	812,441(91)	900,263(92)	338,956(90)	419,377(82)	436,152(94)	662,123(91)
Oligochaetes	2,961(<1)	1,974(<1)	1,969(1)	987(<1)	0(0)	4,934(1)
Harpacticoid copepods	26,972(3)	24,998(3)	11,841(3)	35,524(7)	9,868(2)	9,539(1)
Other	50,653(6)	53,943(5)	22,207(6)	56,246(11)	15,788(3)	48,680(7)
						
Increasing Salinity						

* Numbers in parentheses are the percentage of meiobenthic standing stock size accounted for by particular taxa.

Table 18. Summary of the proportion of the spatial variation in standing stock size of selected meiobenthic taxa explained by the physical/chemical factors monitored

	Bottom Water Characteristics			Sediment Characteristics				Total Variance Explained by Regression (r ²)	
	Salinity (ppt)	Temperature (°C)	Dissolved Oxygen (ppm)	Interstitial Salinity (ppt)	Moisture Content (%)	Available Carbon Content (%)	Total Carbon Content (%)		Silt-Clays Content (%)
<u>July 1979</u>									
Nematodes									
All stations								0.27	0.27
Reference stations								0.72	0.72
Oligochaetes									
All stations	No relationships observed between the measured physical variables and oligochaete standing stock size.								
Reference stations								0.63	0.16
<u>January 1980</u>									
Nematodes									
All stations	No relationships observed between the measured physical variables and nematode standing stock size.							0.31	0.31
Reference stations									
Harpacticoid copepods									
All stations				0.28					
Reference stations	0.50								

Table 19. Model statistics derived from stepwise linear regression for the numerically dominant meio-benthic taxa*

Taxon	July 1979	
	Reference Stations Only	All Stations
Nematodes	$\alpha = 24.61264$ $\beta_1(\text{silt-clay content}) = -22.29738 \pm 5.20056$	$\alpha = 16.69620$ $\beta_1(\text{silt-clay content}) = -13.64178$
Oligochaetes	$\alpha = -69.65945$ $\beta_1(\text{salinity}) = 1.93065 \pm 0.67771$ $\beta_2(\text{silt-clay content}) = 63.91711 \pm 30.98718$	na
Harpacticoid copepods	na	na

* The general model is $\ln(\hat{Y}) = \alpha + \beta_1 (\text{measured value of physical/chemical factor}) + \beta_2 (\text{measured value of physical/chemical factor})$ where $\ln(\hat{Y})$ is the natural logarithm of the predicted density of standing stock size. Confidence limits indicated for the β 's are \pm one standard error.

na = not analyzed

Table 19. Continued

Taxon	January 1979	
	Reference Stations Only	All Stations
Nematodes	na	$\alpha = 8.60479$ β_1 (silt-clay = -2.69681 content)
Oligochaetes	na	na
Harpacticoid copepods	na	$\alpha = 0.77542$ β_1 (interstitial = 0.40252 \pm 0.16656 salinity)

na = not analyzed

Table 20. Vertical and longitudinal distribution of ATP in Patuxent estuary sediments during July 1979 ($\mu\text{g ATP/g dry sediment weight}$)*

Station	Replicate	Sediment-Water Interface	5-cm Depth	25-cm Depth
Holland Cliffs (station 10)	1	0.360	0.137	0.123
	2	1.258	0.326	2.109*
	3	<u>0.380</u>	<u>0.196</u>	<u>0.090</u>
	\bar{X}	0.666	0.220	0.107
Eagle Harbor (station 9)	1	1.005	0.339	0.350
	2	0.547	0.187	0.408
	3	<u>0.351</u>	<u>0.493</u>	<u>0.429</u>
	\bar{X}	0.634	0.340	0.396
Potts Point (station 8)	1	1.347	0.299	0.396
	2	1.402	0.369	0.540
	3	<u>2.211</u>	<u>1.490</u>	<u>0.509</u>
	\bar{X}	1.653	0.719	0.482
Chalk Point (station 41)	1	1.315	0.467	0.740
	2	2.442	0.522	0.345
	3	<u>2.295</u>	<u>0.549</u>	<u>0.291</u>
	\bar{X}	2.017	0.513	0.459
Teague Point (station 5)	1	2.720	1.820	0.272
	2	2.570	1.217	0.849
	3	<u>4.967*</u>	<u>1.013</u>	<u>0.849</u>
	\bar{X}	3.419	1.350	0.657
Sheridan Point (downstream) (station 3)	1	3.202	0.601	0.356
	2	2.422	0.180	0.214
	3	<u>2.763</u>	<u>0.364</u>	<u>0.149</u>
	\bar{X}	2.796	0.382	0.240
Overall Mean		1.864	0.587	0.240
Percent of surface ATP			31.5%	20.9%

*Potential outliers.

Table 21. Vertical distribution of ATP in Osborn Cove sediments during July 1979 ($\mu\text{g ATP/g dry sediment weight}$)

Sediment Type	Replicate	Sediment-Water Interface	5-cm Depth	25-cm Depth
Sand	1	0.119	0.040	0.008
	2	0.171	0.006	0.147*
	3	<u>0.092</u>	<u>0.033</u>	<u>0.007</u>
	\bar{X}	0.127	0.026	0.008
Muddy-sand	1	0.183	0.067	0.005
	2	0.152	0.179	0.031
	3	<u>0.108</u>	<u>0.028</u>	<u>0.018</u>
	\bar{X}	0.148	0.091	0.018
Mud	1	0.161	0.022	0.014
	2	0.170	0.031	0.017
	3	<u>0.174</u>	<u>0.116</u>	<u>0.052</u>
	\bar{X}	0.168	0.056	0.028
Overall mean		0.148	0.058	0.018
Percent of surface ATP		--	39.2%	12.2%

*Potential outlier.

Table 22. Partitioned ATP values from the main stem of the Patuxent estuary

Station	µg ATP per g dry weight of surface sediment	Number of surface dwelling macrobenthic organisms per g dry weight of surface sediment	µg of ATP per g dry weight of surface sediment due to macrobenthic organisms (a)	Percent of ATP in surface sediments due to macrobenthic organisms	Number of meiobenthic organisms per g dry weight of surface sediment	µg ATP per g dry weight of surface sediment due to meiobenthic organisms (b)	Percent ATP in surface sediments due to meiobenthic organisms	Number of bacteria (c) per g dry weight of surface sediment, if all unaccounted ATP were due to bacteria
3	1.796	0.12	0.025	1	5.5	0.110-0.017	4	3.0×10^9
5	3.419	0.12	0.025	1	4.4	0.088-0.013	3	3.8×10^9
41	2.017	0.25	0.050	3	2.6	0.052-0.008	3	2.2×10^9
8	1.653	0.50	0.100	6	5.2	0.104-0.016	6	1.7×10^9
9	0.634	0.50	0.100	16	5.7	0.114-0.017	18	4.7×10^8
10	0.666	0.25	0.250	8	1.1	0.022-0.003	3	6.7×10^8

(a) A value of 200 ng ATP per individual macrobenthic organism was used in these calculations. This value is probably high since the only macrobenthic organisms likely to have been included in ATP samples were very small oligochaetes containing considerably less than 200 ng of ATP per individual.

(b) The range of ATP per individual meiobenthic organism was varied from 20 ng per individual to 3 ng per individual and encompasses the range of values reported in the literature for nematodes and oligochaetes.

(c) An average value of 8.8×10^{-16} g of ATP per bacterial cell was assumed in these calculations.

Table 23. Partitioned ATP values from Osborn Cove samples.

Sediment Type	µg ATP per g dry weight of surface sediment	Estimated number of meiobenthic organisms per g dry weight of surface sediment	µg ATP per g dry weight of surface sediment due to meiobenthic organisms ^(a)	Percent of ATP in surface sediment due to meiofauna, assuming decimal point error in reported ATP values	µg ATP per g dry weight of surface sediment due to bacteria, assuming decimal point error in reported ATP values and conservative estimate of ATP per meiofaunal organism	Estimated number of bacteria per g dry weight of surface sediment, assuming decimal point error in reported ATP values ^(b)
Sand	0.127	86	0.26-1.72	20-100	1.01	1.1×10^9
Muddy-sand	0.148	65	0.20-1.30	14-100	1.28	1.5×10^9
Mud	0.168	85	0.26-1.72	16-100	1.42	1.6×10^9

(a) The range of ATP per individual meiobenthic organism was varied from 20 ng per individual to 3 ng per individual and encompasses the range of values observed in the literature for nematodes.

(b) An average value of 8.8×10^{-16} g of ATP per bacterial cell was assumed to make this calculation.

Table 24. Summary of the reproductive activity of Cyathura polita

Date	Station	No. Per m ²	No. Per m ² Bearing Young	Percent Bearing Young	No. Newly Released Young Per m ² *	Percent Newly Released Young
April 1978	5	52	0	0	0	0
	6	316	0	0	0	0
	7	124	0	0	0	0
	8	158	0	0	0	0
May 1978	5	94	2	2	0	0
	6	334	56	17	0	0
	7	212	36	17	0	0
	8	136	24	18	2	~1
June 1978	5	258	16	6	156	60
	6	659	43	7	368	56
	7	600	12	2	472	79
	8	243	0	0	152	63
July 1978	5	96	0	0	0	0
	6	538	6	1	88	16
	7	402	2	<1	50	12
	8	214	0	0	24	11
August 1978	5	82	0	0	8	10
	6	558	0	0	10	2
	7	394	4	1	38	10
	8	194	0	0	10	15
September 1978	5	104	6	6	8	8
	6	420	2	<1	58	14
	7	314	4	1	48	15
	8	206	4	2	20	10

* Newly released young is defined as animals belonging to a small size group not present in the population of the previous sampling period.

Table 24. Continued

Date	Station	No. Per m ²	No. Per m ² Bearing Young	Percent Bearing Young	No. Newly Released Young Per m ² *	Percent Newly Released Young
October 1978	5	98	0	0	0	0
	6	530	2	<1	0	0
	7	274	0	0	0	0
	8	258	0	0	0	0
November 1978	5	170	0	0	0	0
	6	450	0	0	0	0
	7	232	0	0	0	0
	8	222	0	0	0	0
December 1978	5	160	0	0	0	0
	6	422	0	0	0	0
	7	334	0	0	0	0
	8	280	0	0	0	0
January 1979	5	24	0	0	0	0
	6	308	0	0	0	0
	7	126	0	0	0	0
	8	166	0	0	0	0
February 1979	5	138	0	0	0	0
	6	282	0	0	0	0
	7	180	0	0	0	0
	8	62	0	0	2	1

Table 24. Continued

Date	Station	No. Per m ²	No. Per m ² Bearing Young	Percent Bearing Young	No. Newly Released Young Per m ² *	Percent Newly Released Young
March 1979	5	38	0	0	0	0
	6	304	0	0	0	0
	7	120	0	0	0	0
	8	160	0	0	0	0
April 1979	5	86	0	0	0	0
	6	266	0	0	0	0
	7	118	0	0	0	0
	8	134	0	0	0	0
May 1979	5	34	0	0	0	0
	6	502	6	1	148	29
	7	192	2	1	90	47
	8	356	6	2	252	71

Table 25. Summary of data (numbers per m²) collected in 1978 near station 5 for macrobenthic standing stocks in an area from which predators were excluded and in an adjacent reference area*

Species	April (start)	May		June		August	
		outside	inside	outside	inside	outside	inside
<u>Callinectes sapidus</u>	-	-	1	-	1	-	1
<u>Corophium lacustre</u>	-	-	8	50	633	-	-
<u>Cyathura polita</u>	400	250	383	1383	1041	383	200
<u>Elotea triloba</u>	17	8	17	66	17	8	67
<u>Gammarus</u> sp.	25	8	-	17	8	8	-
<u>Heteromastus filiformis</u>	733	666	950	1450	1119	575	650
<u>Ilypaniola grayi</u>	-	-	-	33	75	-	50
<u>Iaeonereis culveri</u>	216	92	125	100	116	67	50
<u>Leptocheirus plumulosus</u>	108	1058	341	2683	900	175	-
<u>Limnodrilus hoffmeisteri</u>	175	50	58	175	75	116	100
<u>Macoma balthica</u>	650	583	408	650	166	167	-
<u>Macoma phenax</u>	225	225	266	300	83	50	116
<u>Melita nitida</u>	-	-	-	-	-	17	-
<u>Monoculodes edwardsi</u>	-	50	-	25	33	-	-
<u>Mya arenaria</u>	25	50	-	-	8	-	-

* A large blue crab was noted inside the cage during May and small crabs (Rhithropanopeus harrisi) were noted inside the cages during August.

Table 25. Continued


Species	April (start)	May		June		August	
		outside	inside	outside	inside	outside	inside
<u>Nereis succinea</u>	17	33	25	25	33	50	42
<u>Tubificodes heterochaetus</u>	250	316	491	125	75	458	1000
<u>Polydora sp.</u>	-	-	-	-	-	-	200
<u>Rangia cuneata</u>	-	-	-	-	-	17	17
<u>Rhithropanopeus harrisii</u>	-	-	-	-	-	-	67
<u>Scolecopides viridis</u>	300	241	116	108	200	67	8
<u>Streblospio benedicti</u>	8	-	17	-	8	17	25
Tendipedidae larvae	-	8	-	25	-	8	-
Unidentified nemertean	133	83	133	58	83	42	92
TOTALS							
Number of species	15	16	15	17	19	17	16
Number of individuals	2682	3721	3339	7281	4674	2225	2585
Predator enclosure							

Table 26. Summary of data (numbers per m²) collected in 1978 near the Chalk Point discharge effluent for macrobenthic standing stocks in an area from which predators were excluded and in an adjacent reference area*

Species	April (start)	May		June		July	
		outside	inside	outside	inside	outside	inside
<u>Corophium lacustre</u>	17	92	25	17	-	-	25
<u>Cyathura polita</u>	75	75	100	458	1008	83	116
Dipteran larvae	-	-	-	-	-	8	-
<u>Edotea triloba</u>	-	-	-	8	8	-	-
<u>Gammarus</u> sp.	-	92	183*	8	33	-	-
<u>Heteromastus filiformis</u>	116	50	158*	141	358	25	25
<u>Hypaniola grayi</u>	-	-	-	-	-	-	-
<u>Laeonereis culveri</u>	-	-	-	8	8	-	-
<u>Leptocheirus plumulosus</u>	183	733	2275*	2575	3850	158	8
<u>Limnodrilus hoffmeisteri</u>	-	-	-	-	-	8	17
<u>Macoma balthica</u>	50	117	725*	58	141	33	-
<u>Macoma phenax</u>	8	50	50	42	83	25	8
<u>Melita nitida</u>	-	-	-	17	8	-	-
<u>Monoculodes edwardsi</u>	-	-	17	42	208	-	-
<u>Mya arenaria</u>	-	-	-	-	-	-	-

* Small crabs (Rhithropanopeus harrisii) gained access to the cage some time prior to the June sampling.

Table 26. Continued


Species	April (start)	May		June		July	
		outside	inside	outside	inside	outside	inside
<u>Neomysis americana</u>	-	-	-	-	75	8	-
<u>Nereis succinea</u>	-	-	-	-	33	8	-
<u>Polydora</u> sp.	-	-	8	-	-	-	17
<u>Rangia cuneata</u>	-	-	-	-	-	8	-
<u>Rhithropanopeus harrisii</u>	-	-	-	-	25	-	125
<u>Scolecoides viridis</u>	25	17	83	17	17	8	8
<u>Streblospio benedicti</u>	-	-	-	-	-	-	-
<u>Stylochus ellipticus</u>	-	-	-	-	-	-	-
Tendipedidae larvae	8	17	42	24	75	66	33
Tubificoides heterochaetus	125	241	1208	583	558	375	383
Unidentified nemertean	50	42	8	58	116	33	33
TOTALS							
Number of species	10	11	13	15	17	14	12
Number of individuals	657	1526	4877	4056	6604	846	798
Predator exclusion							
Predator enclosure							

Table 27. Summary of sediment characteristics inside areas from which predators were excluded and in adjacent uncaged reference areas during 1978 predator exclusion experiments

Location	Sediment Characteristics															
	Moisture Content (%)				Silt-Clay Content (%)				Total Carbon Content (%)				Available Carbon Content (%)			
	Apr	May	Jun	Aug	Apr	May	Jun	Aug	Apr	May	Jun	Aug	Apr	May	Jun	Aug
Uncaged reference area	30.0	22.7	36.9	44.4	30.0	24.8	27.0	33.4	2.0	2.2	0.7	1.3	4.0		4.0	3.8
Inside caged reference area	39.0	38.3	38.9	53.9	26.1	24.0	28.8	14.2	2.1	1.4	0.4	0.7	4.1	Samples were lost	4.5	1.3
Uncaged reference area near discharge site	71.6	71.4	73.2	73.8	93.2	93.2	98.2	98.2	5.0	4.4	2.1	2.6	14.0		14.4	11.8
Inside caged area near discharge site	65.0	67.1	61.1	65.6	98.2	94.6	98.0	96.6	5.1	4.8	2.1	2.3	14.5		14.1	8.1

Table 28. Top of table is a summary of sediment characteristics at Teague Point (near station 5) inside areas from which predators were excluded, in adjacent caged areas that were organically enriched, and at uncaged reference areas (1979-1980).

Location	Sediment Characteristics																			
	Moisture Content (%)					Silt-Clay Content (%)					Total Carbon Content (%)					Available Carbon Content (%)				
	Sep	Oct	Dec	Mar	May	Sep	Oct	Dec	Mar	May	Sep	Oct	Dec	Mar	May	Sep	Oct	Dec	Mar	May
Uncaged reference area	42.2	58.0	41.8	78.7	56.7	38.8	42.0	41.2	46.0	29.2	4.3	5.2	5.2	7.6	4.2	1.9	1.2	0.2	2.2	1.2
Caged area (control)	57.4	62.1	54.7	64.1	47.4	42.3	41.4	42.7	56.3	39.8	7.8	7.5	10.9*	8.8	8.1	2.1	1.8	3.2	2.1	3.0
Organically enriched caged area	52.6	46.6	57.8	41.8	49.7	42.3	38.5	40.8	50.4	40.6	6.9	7.9	8.5	12.1*	7.3	0.8	1.3	1.6	3.6	3.1
Estuary sediments in caged area	-	58.8	73.7	66.1	60.7	-	69.0	73.0	74.4	80.4	-	7.9	10.3	10.7*	7.7	-	2.3	2.2	2.1	2.7
Estuary sediments in estuary	-	61.4	75.0	71.7	62.3	-	94.3	85.8	92.3	91.3	-	8.7	9.2	9.1	8.9	-	3.0	2.8	2.9	2.5
Estuary sediments in canal	-	48.5	52.3	76.2	51.4	-	57.0	68.8	80.0	47.7	-	5.8	7.9	11.3*	5.2	-	1.8	2.2	2.7	1.3
Canal sediments in estuary	-	44.5	69.8	45.6	52.8	-	36.0	69.2	48.8	51.4	-	4.3	7.3	4.7	5.7	-	1.2	2.2	1.4	1.7
Canal sediments in canal	-	44.8	49.5	48.1	41.4	-	46.4	65.6	62.0	23.7	-	4.9	5.7	5.7	2.9	-	1.3	2.0	1.8	0.8

* Total carbon levels that were significantly ($P < 0.05$) higher than would have been predicted based on silt-clay content of sediments in sample.

- Dashes indicate samples have not been processed.

Table 29. Summary of data (number per 200 cm²) of macrobenthic organisms at the uncaged reference area in 1979-1980*

Taxon	September	October	March	May
<u>Corophium</u> sp.	0	0	0.75 ± 0.96	2.00 ± 1.83
<u>Cyathura polita</u>	7.75 ± 3.69	2.50 ± 1.73	0.75 ± 0.50	16.00 ± 14.99
<u>Heteromastus filiformis</u>	8.75 ± 5.91	5.00 ± 4.32	3.50 ± 1.91	10.50 ± 1.73
<u>Hypaniola grayi</u>	0	1.00 ± 0.82	0.25 ± 0.50	0
<u>Leptocheirus plumulosus</u>	0.50 ± 0.58	0	1.25 ± 0.96	52.50 ± 10.91
<u>Limnodrilus hoffmeisteri</u>	8.50 ± 7.19	3.25 ± 4.03	0.50 ± 0.58	1.50 ± 0.58
<u>Macoma balthica</u>	1.00 ± 1.41	1.50 ± 1.29	1.25 ± 0.96	2.25 ± 0.50
<u>Macoma phenax</u>	1.00 ± 0.82	1.00 ± 1.41	1.00 ± 0.82	0.50 ± 1.00
Nemerteans (unidentified)	3.75 ± 4.35	1.75 ± 1.71	3.25 ± 1.26	2.00 ± 2.71
<u>Nereis succinea</u>	3.00 ± 2.00	4.75 ± 4.57	2.00 ± 1.63	3.25 ± 0.96
<u>Scolecoides viridis</u>	3.00 ± 2.16	1.25 ± 0.50	28.25 ± 14.17	35.25 ± 7.93
Tendipedidae larva	0	0.25 ± 0.50	0	5.00 ± 0
<u>Tubificoides heterochaetus</u>	41.75 ± 17.11	9.00 ± 10.42	11.75 ± 8.10	8.50 ± 3.00

* Confidence limits shown are ± one standard deviation.

Table 30. Summary of data (number per m²) of macrobenthic organisms at the area from which predators were excluded by cages in 1979-1980*

Taxon	September	October	March	May
<u>Corophium</u> sp.	0	0	0.75 ± 0.96	6.75 ± 6.70
<u>Cyathura</u> <u>polita</u>	7.75 ± 3.69	2.25 ± 1.26	0.75 ± 0.50	7.25 ± 6.08
<u>Heteromastus</u> <u>filiformis</u>	8.75 ± 5.91	2.25 ± 2.63	3.50 ± 1.91	14.50 ± 4.12
<u>Hypaniola</u> <u>grayi</u>	1.50 ± 1.73	0.25 ± 0.50	0.25 ± 0.50	7.50 ± 5.80
<u>Leptocheirus</u> <u>plumulosus</u>	0.50 ± 0.58	0.50 ± 0.58	1.25 ± 0.96	32.25 ± 10.87
<u>Limnodrilus</u> <u>hoffmeisteri</u>	8.50 ± 7.18	3.75 ± 5.56	0.50 ± 0.58	8.25 ± 2.63
<u>Macoma</u> <u>balthica</u>	1.00 ± 1.41	0.50 ± 0.58	1.25 ± 0.96	1.25 ± 0.50
<u>Macoma</u> <u>phenax</u>	1.00 ± 0.82	0.25 ± 0.50	1.00 ± 0.82	1.75 ± 0.50
Nemerteans (unidentified)	2.50 ± 1.73	3.75 ± 3.10	4.75 ± 4.27	4.25 ± 3.30
<u>Nereis</u> <u>succinea</u>	3.00 ± 2.00	1.75 ± 1.71	2.00 ± 1.63	4.25 ± 3.40
<u>Scolecoides</u> <u>viridis</u>	3.00 ± 2.16	8.25 ± 3.59	28.25 ± 14.17	78.00 ± 32.22
Tendipedidae larva	0	0	0	17.50 ± 21.49
<u>Tubificoides</u> <u>heterochaetus</u>	41.75 ± 17.11	11.00 ± 8.98	11.75 ± 8.10	44.50 ± 17.86

* Confidence limits shown are ± one standard deviation.

Table 31. Null probabilities of F statistics of ANOVA's testing for station differences (i.e., probability of no effect of predator exclusion) between an uncaged reference area and an area from which predators were excluded by cages in 1979-1980

Taxon	September	October	March	May
<u>Corophium</u> sp.	--	--	0.006*	0.341
<u>Cyathura polita</u>	1.000	0.946	0.003*	0.414
<u>Heteromastus filiformis</u>	1.000	0.278	0.983	0.140
<u>Hypaniola grayi</u>	0.134	0.169	0.537	0.002*
<u>Leptocheirus plumulosus</u>	1.000	0.134	0.647	0.066
<u>Limnodrilus hoffmeisteri</u>	1.000	0.993	0.158	<0.001*
<u>Macoma balthica</u>	1.000	0.261	0.295	0.023*
<u>Macoma phenax</u>	1.000	0.390	0.763	0.049*
Nemertean (unidentified)	0.846	0.287	0.976	0.272
<u>Nereis succinea</u>	1.000	0.427	0.976	0.845
<u>Scolecoides viridis</u>	1.000	0.001*	0.744	0.035*
Tendipedidae larva	--	0.356	0.134	0.438
<u>Tubificoides heterochaetus</u>	1.000	0.737	0.073	0.001*

* Differences that were significant at the 0.05 level.

-- Species not present in samples

Table 32. Null probabilities of MANOVA statistics testing for station differences (i.e., probability of no effect of predator exclusion) in macrobenthic community structure between an area from which predators were excluded by cages and an uncaged reference area in 1979-1980

Test Statistic	September	October	March	May
Hotelling-Lawley Trace	0.575	0.146	0.006*	0.035*
Pillai's Trace	0.575	0.146	0.006*	0.035*
Wilks' Criterion	0.575	0.146	0.006*	0.035*

* Effects that were significant at the 0.05 level.

Table 33. Null probabilities of F statistics of ANOVA's testing for all hypotheses for macrobenthic data collected between September 1979 and May 1980 (entire data set) in an area from which predators were excluded by cages and in an uncaged reference area

Taxon	Effect		
	Station (S)	Month (M)	S·M
<u>Corophium</u> sp.	0.014*	<0.001*	0.065
<u>Cyathura polita</u>	0.544	0.001*	0.089
<u>Heteromastus filiformis</u>	0.620	0.002*	0.481
<u>Hypaniola grayi</u>	0.002*	0.025*	<0.001*
<u>Leptocheirus plumulosus</u>	0.537	<0.001*	0.242
<u>Limnodrilus hoffmeisteri</u>	0.061	0.003*	0.209
<u>Macoma balthica</u>	0.094	0.203	0.791
<u>Macoma phenax</u>	0.476	0.456	0.129
Nemertean (unidentified)	0.325	0.851	0.686
<u>Nereis succinea</u>	0.672	0.607	0.829
<u>Scolecopides viridis</u>	0.001*	<0.001*	0.011*
Tendipedidae larva	0.320	0.001*	0.483
<u>Tubificoides heterochaetus</u>	0.006*	0.001*	0.118

* Effects that were significant at the 0.05 level.

Table 34. Null probabilities of MANOVA statistics testing for all hypotheses for macrobenthic data collected between September 1979 and May 1980 (entire data set) in an area from which predators were excluded by cages and in an uncaged reference area

Effect	Test Statistic		
	Hotelling-Lawley Trace	Pillai's Trace	Wilks' Criterion
Station (S)	0.005*	0.005*	0.005*
Month (M)	<0.001*	<0.001*	<0.001*
S·M	0.022*	0.020*	0.018*

* Effects that were significant at the 0.05 level.

Table 34. Null probabilities of MANOVA statistics testing for all hypotheses for macrobenthic data collected between September 1979 and May 1980 (entire data set) in an area from which predators were excluded by cages and in an uncaged reference area

Effect	Test Statistic		
	Hotelling-Lawley Trace	Pillai's Trace	Wilks' Criterion
Station (S)	0.005*	0.005*	0.005*
Month (M)	<0.001*	<0.001*	<0.001*
S·M	0.022*	0.020*	0.018*

* Effects that were significant at the 0.05 level.

Table 35. Continued

Taxon	Month (M)	Effect	M·P
		Predator Exclusion (P)	
<u>Scolecoides viridis</u>	0.001*	0.764	0.579
<u>Streblospio benedicti</u>	0.001*	0.767	0.964
<u>Stylochus ellipticus</u>	0.149	0.052*	0.149
<u>Tanaidae</u> larvae	0.334	0.572	0.801
Tendipedidae larvae	0.001*	0.034*	0.172
<u>Tubificoides heterochaetus</u>	0.018*	0.159	0.192
Unidentified gastropod	0.418	0.332	0.418
Unidentified leech species	0.550	0.197	0.550
Unidentified nemertean	0.275	0.397	0.352

Table 36. Null probabilities of MANOVA statistics testing for all hypotheses for macrobenthic recolonization data collected between October 1979 and May 1980 (entire data set) in an area where predators were excluded by cages and in an adjacent uncaged reference area.

Effect	Test Statistic		
	Hotelling-Lawley Trace	Pillai's Trace	Wilks' Criterion
Predator exclusion (P)	0.1527	0.1527	0.1527
Month (M)	0.0520*	0.0001*	0.0002*
P•M	0.1135	0.1058	0.0205*

* Effects that were significant at the 0.05 level.

Table 37. Null probabilities of F statistics of ANOVA's testing for station effects (i.e., probability of no effects of predator exclusion) for macrobenthic recolonization data collected approximately one (October), three (December), six (March), and nine (May) months after deployment of "azoic" sediments in an area where predators were excluded by cages and in an adjacent uncaged reference area.

Taxon	October	December	March	May
<u>Balanus</u> sp.	-	0.374	-	0.512
<u>Corophium</u> sp.	0.001*	0.072	0.400	0.269
<u>Cyathura</u> <u>polita</u>	0.027*	0.056	0.022*	0.179
Dipteran pupae	0.374	0.374	-	-
<u>Edotea</u> <u>triloba</u>	0.407	0.374	0.311	0.197
<u>Gammarus</u> sp.	1.000	0.597	0.061	0.041*
<u>Gemma</u> <u>gemma</u>	0.374	-	-	-
<u>Heteromastus</u> <u>filiformis</u>	0.374	0.921	0.128	0.921
<u>Hypaniola</u> <u>grayi</u>	0.514	0.113	0.841	0.005*
<u>Leptocheirus</u> <u>plumulosus</u> ^(a)	0.414	1.000	0.414	0.414
<u>Limnodrilus</u> <u>hoffmeisteri</u>	-	0.136	0.257	0.012*
<u>Macoma</u> <u>balthica</u>	-	-	-	0.246
<u>Macoma</u> <u>phenax</u>	0.198	0.468	0.600	0.435
<u>Melita</u> <u>nitida</u>	-	-	-	0.121
<u>Mulinia</u> <u>lateralis</u>	0.374	-	-	0.116
<u>Nereis</u> <u>succinea</u>	0.972	0.377	0.099	0.217
<u>Palaemonetes</u> <u>pugio</u>	0.374	-	-	-
<u>Rangia</u> <u>cuneata</u>	0.374	-	0.374	0.002*
<u>Rhithropanopeus</u> <u>harrisii</u>	0.407	-	-	0.867

* Effects that were significant at the 0.05 level.

(a) Variances could not be homogenized for this species by transformation and were not included in MANOVA analyses. Nonparametric ANOVA was used to test hypotheses concerning this species.

Table 37. Continued

Taxon	October	December	March	May
<u>Scolecoides viridis</u>	0.136	0.826	0.750	0.223
<u>Streblospio benedicti</u>	-	-	-	0.779
<u>Stylochus ellipticus</u>	-	0.374	-	0.136
<u>Tanaidae</u> larvae	-	0.374	1.000	-
Tendipedidae larvae	0.588	0.450	0.208	0.012*
<u>Tubificoides heterochaetus</u>	0.374	0.947	0.445	0.020*
Unidentified gastropod	-	-	-	0.374
Unidentified leech species	-	-	0.374	0.374
Unidentified nemertean	0.374	0.874	0.156	0.415

Table 38. Null probabilities of MANOVA statistics testing for station effects (i.e., probability of no effects of predator exclusion) for macrobenthic recolonization data collected one (October), three (December), six (March), and nine (May) months after deployment of "azoic" sediments in an area where predators were excluded by cages and in an adjacent uncaged reference area.

Test Statistic	October	December	March	May
Hotelling-Lawley Trace	0.033*	0.112	0.065	0.029*
Pillai's Trace	0.033*	0.112	0.065	0.029*
Wilks' Trace	0.033*	0.112	0.065	0.029*

* Effects that were significant at the 0.05 level.

Table 39. Null probabilities of F statistics of ANOVA's testing for hypotheses from meiobenthic recolonization data collected between October 1979 and May 1980 (entire data set) at an area where predators were excluded by cages and at an adjacent uncaged reference area

Taxon	Effect			
	Month (M)	Predator Exclusion (P)	M·P	Tray
<u>Acoela</u> sp. (a)	<0.006*	0.157	0.572	N/A
Amphipod juveniles	0.001*	0.577	0.808	0.036*
Barnacle cypris	0.299	0.978	0.731	0.473
Barnacle zoea	0.027*	0.063	0.027*	0.935
Bivalve juveniles	0.402	0.127	0.347	0.721
Bivalve larvae	0.418	0.332	0.418	0.473
Calanoid copepods	0.418	0.332	0.418	0.473
Calanoid nauplii	0.003*	0.063	0.021*	0.087
Ciliates	<0.001*	0.006*	0.004*	0.900
Cladocerans	0.080	0.119	0.080	0.838
<u>Foraminifera</u> sp. 1	0.505	0.616	0.124	0.417
<u>Foraminifera</u> sp. 2	0.418	0.332	0.418	0.473
Harpacticoid copepods (a)	0.023*	0.004*	0.202	N/A
Hydracarians	0.418	0.332	0.418	0.473
Hydrozoans	<0.001*	0.003*	0.001*	0.993
Isopod juveniles	0.418	0.332	0.418	0.473
Nematodes (a)	<0.001*	0.346	0.931	N/A
<u>Nereis</u> larvae and juveniles	0.020*	0.486	0.473	0.001*

* Effects that were significant at the 0.05 level.

(a) Indicates taxa whose variances could not be homogenized by transformation and were not included in MANOVA analyses. Nonparametric ANOVA was used to test hypotheses concerning these taxa.

Table 38. Null probabilities of MANOVA statistics testing for station effects (i.e., probability of no effects of predator exclusion) for macrobenthic recolonization data collected one (October), three (December), six (March), and nine (May) months after deployment of "azoic" sediments in an area where predators were excluded by cages and in an adjacent uncaged reference area.

Test Statistic	October	December	March	May
Hotelling-Lawley Trace	0.033*	0.112	0.065	0.029*
Pillai's Trace	0.033*	0.112	0.065	0.029*
Wilks' Trace	0.033*	0.112	0.065	0.029*

* Effects that were significant at the 0.05 level.

Table 39. Null probabilities of F statistics of ANOVA's testing for hypotheses from meiobenthic recolonization data collected between October 1979 and May 1980 (entire data set) at an area where predators were excluded by cages and at an adjacent uncaged reference area

Taxon	Month (M)	Effect		
		Predator Exclusion (P)	M·P	Tray
<u>Acoela</u> sp. (a)	<0.006*	0.157	0.572	N/A
Amphipod juveniles	0.001*	0.577	0.808	0.036*
Barnacle cypris	0.299	0.978	0.731	0.473
Barnacle zoea	0.027*	0.063	0.027*	0.935
Bivalve juveniles	0.402	0.127	0.347	0.721
Bivalve larvae	0.418	0.332	0.418	0.473
Calanoid copepods	0.418	0.332	0.418	0.473
Calanoid nauplii	0.003*	0.063	0.021*	0.087
Ciliates	<0.001*	0.006*	0.004*	0.900
Cladocerans	0.080	0.119	0.080	0.838
<u>Foraminifera</u> sp. 1	0.505	0.616	0.124	0.417
<u>Foraminifera</u> sp. 2	0.418	0.332	0.418	0.473
Harpacticoid copepods (a)	0.023*	0.004*	0.202	N/A
Hydracarians	0.418	0.332	0.418	0.473
Hydrozoans	<0.001*	0.003*	0.001*	0.993
Isopod juveniles	0.418	0.332	0.418	0.473
Nematodes (a)	<0.001*	0.346	0.931	N/A
<u>Nereis</u> larvae and juveniles	0.020*	0.486	0.473	0.001*

* Effects that were significant at the 0.05 level.

(a) Indicates taxa whose variances could not be homogenized by transformation and were not included in MANOVA analyses. Nonparametric ANOVA was used to test hypotheses concerning these taxa.

Table 41. Null probabilities of F statistics of ANOVA's testing for station effects (i.e., probabilities of no effect of predator exclusion) for meiobenthic recolonization data collected approximately one (October) month after the start of the experiment at an area where predators were excluded by cages and at an uncaged reference area.

Taxon	Effect	
	Predator Exclusion	Tray
<u>Acoela</u> sp. ^(a)	0.157	N/A
Amphipod juveniles	1.000	0.445
Barnacle cypris	0.690	0.445
Bivalve juveniles	0.133	0.710
Calanoid nauplii	0.381	0.034*
Ciliates	0.670	0.596
<u>Foraminifera</u> sp. 1	0.228	0.744
<u>Foraminifera</u> sp. 2	0.374	0.445
Harpacticoid copepods ^(a)	0.001*	N/A
Hydracarians	0.374	0.445
Hydrozoans	0.024*	0.903
Isopods	0.374	0.445
Nematodes ^(a)	0.157	N/A
Ostracods ^(a)	0.018*	N/A
Oligochaetes	0.181	0.729
Polychaete larvae	0.374	0.445
Rotifers	0.311	0.681
Tendipedidae larvae	0.374	0.445
Unidentified flatworm	0.374	0.027*

* Effects that were significant at the 0.05 level.

(a) Indicates taxa whose variances could not be homogenized by transformation and were not included in MANOVA analyses. Nonparametric ANOVA was used to test hypotheses concerning these taxa.

Table 42. Null probabilities of MANOVA statistics testing for all hypotheses for meiobenthic recolonization data collected one (October), three (December), six (March), and nine (May) months after the start of the experiment at an area where predators were excluded by cages at an adjacent uncaged reference area

Month	Effect	Test Statistic		
		Hotelling-Lawley Trace	Pillai's Trace	Wilks' Criterion
October	Predator exclusion	0.0865	0.0865	0.0865
	Tray	0.9921	0.9618	0.9806
December	Predator exclusion	0.0469*	0.0469*	0.0469*
	Tray	0.6837	0.5479	0.6044
March	Predator exclusion	0.1709	0.1709	0.1709
	Tray	0.8980	0.8279	0.8581
May	Predator exclusion	0.1043	0.1043	0.1043
	Tray	0.2002	0.2721	0.2245

* Effects that were significant at the 0.05 level.

Table 43. Null probabilities of F statistics of ANOVA's testing for station effects (i.e., probability of no effect of predator exclusion) for meiobenthic recolonization data collected approximately three months (December) after the start of the experiment at an area where predators were excluded by cages and at an uncaged reference area

Taxon	Effect	
	Predator Exclusion	Tray
<u>Acoela</u> sp. ^(a)	0.637	N/A
Barnacle cypris	0.374	0.445
Bivalve juveniles	0.374	0.445
Bivalve larvae	0.374	0.445
Calanoid copepods	0.374	0.445
Calanoid nauplii	0.057	0.568
Ciliates	0.001*	0.694
<u>Foraminifera</u> sp. 1	0.503	0.035*
Harpacticoid copepods ^(a)	0.157	N/A
Hydrozoans	0.374	0.445
Nematodes ^(a)	0.637	N/A
Ostracods ^(a)	0.157	N/A
Oligochaetes	0.469	0.090
Polychaete larvae	0.013	0.750
Rotifers	0.042*	0.361

* Effects that were significant at the 0.05 level.

(a) Indicates taxa whose variances could not be homogenized by transformation and were not included in MANOVA analyses. Nonparametric ANOVA was used to test hypotheses concerning these taxa.

Table 44. Null probabilities of F statistics of ANOVA's testing for station effects (i.e., probability of no effect of predator exclusion) for meiobenthic recolonization data collected six (March) months after the start of the experiment at an area where predators were excluded by cages and at an uncaged reference area

Taxon	Effect	
	Predator Exclusion	Tray
<u>Acoela</u> sp. (a)	0.637	N/A
Barnacle zoea	0.116	0.737
Calanoid copepods	0.861	0.497
Calanoid nauplii	0.598	0.686
Ciliates	0.236	0.860
Cladocerans	0.175	0.646
<u>Foraminifera</u> sp. 1	0.606	0.588
Harpacticoid copepods (a)	0.001*	N/A
Nematodes (a)	0.637	N/A
<u>Nereis</u> larvae and juveniles	0.374	0.445
Ostracods (a)	0.637	N/A
Oligochaetes	0.139	0.334
Polychaete larvae	0.193	0.704
Rotifers	0.189	0.751
Tardigrades	0.374	0.445
Tendipedidae larvae	1.000	0.445

* Effects that were significant at the 0.05 level.

(a) Indicates taxa whose variances could not be homogenized by transformation and were not included in MANOVA analyses. Nonparametric ANOVA was used to test hypotheses concerning these taxa.

Table 45. Null probabilities of F statistics of ANOVA's testing for station effects (i.e., probability of no effect of predator exclusion) for meiobenthic recolonization data collected nine (May) months after the start of the experiment at an area where predators were excluded by cages and at an uncaged reference area

Taxon	Effect	
	Predator Exclusion	Tray
<u>Acoela</u> sp. ^(a)	0.637	N/A
Amphipod juveniles	0.592	0.150
Bivalve juveniles	1.000	0.445
Calanoid copepods	0.298	0.183
Calanoid nauplii	0.063	0.006*
Ciliates	0.803	0.419
<u>Foraminifera</u> sp. 1	0.074	0.216
Harpacticoid copepods ^(a)	0.157	N/A
Nematodes ^(a)	0.157	N/A
<u>Nereis</u> larvae and juveniles	0.427	0.014*
Ostracods ^(a)	0.157	N/A
Oligochaetes	0.679	0.034*
Polychaete larvae	0.460	0.026*
Rotifers	0.001*	0.953
Tendipedidae larvae	0.064	0.084

* Effects that were significant at the 0.05 level.

(a) Indicates taxa whose variances could not be homogenized by transformation and were not included in MANOVA analyses. Nonparametric ANOVA was used to test hypotheses concerning these taxa.

Table 46. Null probabilities of F statistics of ANOVA's testing all hypotheses for meiobenthic recolonization data collected between October 1979 and May 1980 (entire data set).

Taxon	Effect						
	Month (M)	Sediment Source (S)	Location (L)	M·S	M·L	S·L	M·S·L
<u>Balanus</u> sp. ^(a)	0.033*	0.005*	0.003*	0.027*	0.002*	0.326	<0.001*
<u>Corophium</u> sp. ^(a)	<0.001	0.812	<0.001*	0.207	0.008*	0.176	0.240
<u>Cyathura polita</u> ^(a)	<0.001*	<0.001*	<0.001*	<0.001*	0.001*	0.167	0.825
Dipteran pupae ^(a)	0.193	0.674	0.689	0.912	0.917	0.183	0.199
<u>Edotea triloba</u> ^(a)	0.009*	0.211	<0.001*	0.988	0.044*	0.414	0.944
<u>Gammarus</u> sp. ^(a)	<0.001*	0.291	<0.001*	0.231	0.016*	0.724	0.972
<u>Heteromastus filiformis</u> ^(a)	0.006*	0.443	<0.001*	0.198	0.022*	0.758	0.126
<u>Hypaniola grayi</u>	<0.001*	0.024*	<0.001*	0.003*	0.338	0.952	0.821
<u>Leptocheirus plumulosus</u> ^(b)	0.021*	0.238	<0.001*	0.531	0.653	0.242	0.566
<u>Limnodrilus hoffmeisteri</u> ^(a)	<0.001*	0.653	<0.001*	0.309	0.031*	0.029	0.442

* Effects that were significant at the 0.05 level.

(a) Species used in MANOVA as determined by criteria discussed in Analysis Methods section.

(b) Species distribution could not be suitably transformed for parametric statistical analyses. Experimental univariate effects were tested for by using "Wilson's" nonparametric ANOVA. Species were not included in MANOVA analyses.

Table 46. Continued

Taxon	Effect						
	Month (M)	Sediment Source (S)	Location (L)	M·S	M·L	S·L	M·S·L
<u>Macoma balthica</u> ^(a)	0.050*	0.246	0.047*	0.632	0.142	0.395	0.605
<u>Macoma phenax</u> ^(a)	0.807	0.291	<0.001*	0.258	0.729	0.343	0.559
<u>Nereis succinea</u> ^(a)	0.001*	0.713	<0.001*	0.064	<0.001*	0.596	0.427
<u>Palaemonetes pugio</u> ^(a)	<0.001*	0.002*	0.001*	<0.001*	<0.001*	<0.001*	<0.001*
<u>Rangia cuneata</u> ^(a)	<0.001*	0.053*	<0.001*	0.149	<0.001*	0.413	0.827
<u>Rhithropanopeus harrisii</u> ^(a)	0.015*	0.538	0.011*	0.548	0.088	0.581	0.932
<u>Scolecoplepides viridis</u> ^(a)	0.001*	0.361	<0.001*	0.201	0.058	0.027*	0.362
<u>Streblospio benedicti</u> ^(a)	<0.001*	0.908	0.143	1.000	0.048*	1.000	1.000
<u>Tanaidae</u> ^(a)	0.197	0.488	0.047*	0.045*	0.204	0.480	0.048*
<u>Tendipedidae larvae</u> ^(a)	<0.001*	0.544	0.234	0.445	<0.001*	0.260	0.267
<u>Tubificoides heterochaetus</u> ^(a)	<0.001*	0.983	0.896	0.401	0.080	0.399	0.109
Unidentified gastropod ^(a)	0.030*	0.259	0.029*	0.094	0.018*	0.358	0.091

Table 46. Continued

Taxon	Effect						
	Month (M)	Sediment Source (S)	Location (L)	M·S	M·L	S·L	M·S·L
Unidentified nemerteans (a)	0.088	0.738	0.012*	0.802	0.222	0.502	0.898
Unidentified leech(a)	0.259	0.653	0.116	0.916	0.258	0.683	0.964

Table 47. Null probabilities of MANOVA statistics testing for all hypotheses for macrobenthic recolonization data collected between October 1979 and May 1980 (entire data set)

Effect	Test Statistic		
	Hotelling-Lawley Trace	Pillai's Trace	Wilks' Criterion
Month (M)	0.0001*	0.0001*	0.0001*
Sediment source (S)	0.1072	0.1072	0.1072
Location (L)	0.0001*	0.0001*	0.0001*
M·S	0.0001*	0.0145*	0.0013*
L·S	0.0284*	0.0284*	0.0284*
M·L			
M·S·L	0.0001*	0.0048*	0.0001*

* Effects that were significant at the 0.05 level.

Table 48. Null probabilities of F statistics of ANOVA's testing for all hypotheses for macrobenthic recolonization data collected approximately one month after the start of the experiment (October 1979).

Taxon	Effect		
	Sediment Source (S)	Location (L)	S-L
<u>Corophium</u> sp. ^(a)	0.016*	0.002*	0.349
<u>Cyathura polita</u> ^(a)	0.022*	0.001*	0.354
Dipteran pupae	0.680	0.680	0.215
<u>Edotea triloba</u>	0.080	0.004*	0.080
<u>Gammarus</u> sp.	0.763	0.205	0.763
<u>Gemma gemma</u>	0.347	0.347	0.347
<u>Hypaniola grayi</u>	0.500	0.067	0.500
<u>Leptocheirus plumulosus</u> ^(b)	1.000	0.001*	1.000
<u>Limnodrilus hoffmeisteri</u>	0.347	0.347	0.347
<u>Macoma phenax</u> ^(a)	0.147	<0.001*	0.147
<u>Mulinia lateralis</u>	0.347	0.347	0.347
<u>Neomysis americana</u> ^(a)	0.347	0.347	0.347
<u>Nereis succinea</u> ^(a)	0.621	0.122	0.191
<u>Palaemonetes pugio</u> ^(a)	0.347	0.347	0.347
<u>Rangia cuneata</u>	1.000	0.195	1.000

* Effects that were significant at the 0.05 level.

(a) Species used in MANOVA as determined by criteria discussed in Analysis section.

(b) Species distribution could not be suitably transformed for parametric statistical analyses. Experimental univariate effects were tested for using "Wilson's" nonparametric analysis of variance. Species was not included in MANOVA analyses.

Table 48. Continued

Taxon	Effect		S·L
	Sediment Source (S)	Location (L)	
<u>Rhithropanopeus harrisii</u>	0.416	0.211	1.000
<u>Scolecoides viridis</u>	1.000	1.000	0.195
Tendipedidae larvae	0.467	0.933	0.551
<u>Tanaidae</u>	0.081	0.081	0.081
<u>Tubificoides heterochaetus</u>	1.000	0.195	1.000
Unidentified gastropod	0.347	0.347	0.347

Table 49. Null probabilities of MANOVA statistics testing for all hypotheses for macrobenthic recolonization data collected approximately one month after the start of the experiment (October 1979)

Effect	Test Statistic		
	Hotelling-Lawley Trace	Pillai's Trace	Wilks' Criterion
Sediment source (S)	0.0006*	0.0006*	0.0006*
Location (L)	0.0001*	0.0001*	0.0001*
S·L	0.0025*	0.0025*	0.0025*

* Effects that were significant at the 0.05 level.

Table 50. Null probabilities of F statistics of ANOVA's testing for all hypotheses for macrobenthic recolonization data collected approximately three months after the start of the experiment (December 1979-January 1980).

Taxon	Effect		S.L
	Sediment Source (S)	Location (L)	
<u>Balanus</u> sp.	0.634	0.081	0.634
<u>Conger</u> <u>leucophaeta</u>	0.347	0.347	0.347
<u>Corophium</u> sp. (a)	0.482	0.001*	0.059
<u>Cyathura</u> <u>polita</u> (a)	0.190	<0.001*	0.621
<u>Edotea</u> <u>triloba</u>	0.347	0.347	0.347
<u>Gammarus</u> sp. (a)	0.777	0.018*	0.777
<u>Heteromastus</u> <u>filiformis</u>	0.045*	0.008*	0.045*
<u>Hypaniola</u> <u>grayi</u>	0.499	0.091	0.499
<u>Leptocheirus</u> <u>plumulosus</u> (b)	0.248	0.209	1.000
<u>Limnodrilus</u> <u>hoffmeisteri</u>	0.009*	<0.001*	0.123
<u>Macoma</u> <u>phenax</u>	0.380	0.002*	0.380
<u>Nereis</u> <u>succinea</u> (a)	0.011*	<0.001*	0.430
<u>Rangia</u> <u>cuneata</u>	0.347	0.347	0.347
<u>Rhithropanopeus</u> <u>harrisii</u> (a)	0.081	0.081	0.081
<u>Scolecoides</u> <u>viridis</u> (a)	0.460	0.006*	0.117
<u>Stylochus</u> <u>ellipticus</u>	0.347	0.347	0.347
Tendipedidae larvae (a)	0.514	0.002*	0.012*
<u>Tubificoides</u> <u>heterochaetus</u>	0.119	0.119	0.119
Unidentified nemertean	0.783	0.203	0.783

* Effects that were significant at the 0.05 level.

(a) Species used in MANOVA as determined by criteria discussed in Analysis Methods section.

(b) Species distribution could not be suitably transformed for parametric statistical analyses. Experimental univariate effects were tested for by using "Wilson's" nonparametric ANOVA. Species were not included in MANOVA analyses.

Table 50. Null probabilities of F statistics of ANOVA's testing for all hypotheses for macrobenthic recolonization data collected approximately three months after the start of the experiment (December 1979-January 1980).

Taxon	Effect		S.L
	Sediment Source (S)	Location (L)	
<u>Balanus</u> sp.	0.634	0.081	0.634
<u>Congeria leucophaeta</u>	0.347	0.347	0.347
<u>Corophium</u> sp. ^(a)	0.482	0.001*	0.059
<u>Cyathura polita</u> ^(a)	0.190	<0.001*	0.621
<u>Edotea triloba</u>	0.347	0.347	0.347
<u>Gammarus</u> sp. ^(a)	0.777	0.018*	0.777
<u>Heteromastus filiformis</u>	0.045*	0.008*	0.045*
<u>Hypaniola grayi</u>	0.499	0.091	0.499
<u>Leptocheirus plumulosus</u> ^(b)	0.248	0.209	1.000
<u>Limnodrilus hoffmeisteri</u>	0.009*	<0.001*	0.123
<u>Macoma phenax</u>	0.380	0.002*	0.380
<u>Nereis succinea</u> ^(a)	0.011*	<0.001*	0.430
<u>Rangia cuneata</u>	0.347	0.347	0.347
<u>Rhithropanopeus harrisii</u> ^(a)	0.081	0.081	0.081
<u>Scolecoides viridis</u> ^(a)	0.460	0.006*	0.117
<u>Stylochus ellipticus</u>	0.347	0.347	0.347
Tendipedidae larvae ^(a)	0.514	0.002*	0.012*
<u>Tubificoides heterochaetus</u>	0.119	0.119	0.119
Unidentified nemertean	0.783	0.203	0.783

* Effects that were significant at the 0.05 level.

(a) Species used in MANOVA as determined by criteria discussed in Analysis Methods section.

(b) Species distribution could not be suitably transformed for parametric statistical analyses. Experimental univariate effects were tested for by using "Wilson's" nonparametric ANOVA. Species were not included in MANOVA analyses.

Table 52. Continued

Taxon	Sediment Source (S)	Effect	
		Location (L)	S·L
<u>Tubificodes heterochaetus</u>	0.527	0.512	0.352
Unidentified leech	0.870	0.198	0.870
Unidentified nemertean	0.341	0.347	0.347

Table 52. Null probabilities of F statistics of ANOVA's testing for all hypotheses for macrobenthic recolonization data collected approximately six months after the start of the experiment (February-March 1980).

Taxon	Effect		S-L
	Sediment Source (S)	Location (L)	
<u>Balanus</u> sp. ^(a)	<0.001*	<0.001*	<0.001*
<u>Corophium</u> sp.	0.334	0.001*	0.667
<u>Cyathura</u> <u>polita</u> ^(a)	0.081	<0.001*	0.175
<u>Edotea</u> <u>triloba</u>	0.570	0.003*	0.570
<u>Gammarus</u> sp. ^(a)	0.524	<0.001*	0.524
<u>Heteromastus</u> <u>filiformis</u> ^(a)	0.670	0.432	0.432
<u>Hypaniola</u> <u>grayi</u> ^(a)	0.816	0.010*	0.816
<u>Leptocheirus</u> <u>plumulosus</u> ^(b)	1.000	0.001*	1.000
<u>Limnodrilus</u> <u>hoffmeisteri</u> ^(a)	0.907	0.137	0.171
<u>Macoma</u> <u>balthica</u>	0.081	0.081	0.081
<u>Macoma</u> <u>phenax</u>	0.666	0.008*	0.666
<u>Mya</u> <u>arenaria</u>	0.347	0.347	0.347
<u>Nereis</u> <u>succinea</u>	0.146	0.798	0.499
<u>Rangia</u> <u>cuneata</u> ^(a)	1.000	0.195	1.000
<u>Scolecoides</u> <u>viridis</u>	0.280	0.048*	0.792
<u>Stylochus</u> <u>ellipticus</u>	0.347	0.347	0.347
<u>Tanaidae</u>	0.347	0.347	0.347
<u>Tendipedidae</u> larvae ^(a)	0.463	<0.001*	0.463

* Effects that were significant at the 0.05 level.

(a) Species used in MANOVA as determined by criteria discussed in Analysis section.

(b) Species distribution could not be suitably transformed for parametric statistical analyses. Experimental univariate effects were tested for using "Wilson's" nonparametric analysis of variance. Species was not included in MANOVA analysis.

Table 54. Null probabilities of F statistics of ANOVA's testing for all hypotheses for macrobenthic recolonization data collected approximately nine months after the start of the experiment (May-June 1980).

Taxon	Sediment Source (S)	Effect	
		Location (L)	S-L
<u>Balanus</u> sp. (a)	0.361	0.249	0.008*
<u>Corophium</u> sp.	0.327	0.249	0.786
<u>Cyathura polita</u> (a)	<0.001*	<0.001*	0.966
<u>Edotea triloba</u>	0.650	0.080	0.958
<u>Gammarus</u> sp.	0.050*	0.006*	0.916
<u>Heteromastus filiformis</u> (a)	0.120	0.002*	0.735
<u>Hypaniola grayi</u>	0.002*	0.196	0.961
<u>Leptocheirus plumulosus</u> (b)	0.197	0.010*	1.000
<u>Limnodrilus hoffmeisteri</u>	0.468	0.356	0.506
<u>Macoma balthica</u>	0.717	0.226	0.983
<u>Macoma phenax</u> (a)	0.464	0.004*	0.234
<u>Melita nitida</u>	0.289	0.635	0.506
<u>Nereis succinea</u>	0.595	<0.001*	0.675
<u>Rangia cuneata</u>	0.008*	<0.001*	0.314
<u>Rhithropanopeus harrisii</u>	0.502	0.123	0.869
<u>Scolecoides viridis</u> (a)	0.334	0.006*	0.009*
<u>Streblospio benedicti</u>	0.914	0.187	1.000

* Effects that were significant at the 0.05 level.

(a) Species used in MANOVA as determined by criteria discussed in Analysis section.

(b) Species distribution could not be suitably transformed for parametric statistical analyses. Experimental univariate effects were tested for using "Wilson's" nonparametric analysis of variance. Species was not included in MANOVA analyses.

Table 53. Null probabilities of MANOVA statistics testing for all hypotheses for macrobenthic recolonization data collected approximately six months after the start of the experiment (February-March 1980)

Effect	Test Statistic		
	Hotelling-Lawley Trace	Pillai's Trace	Wilks' Criterion
Sediment source (S)	0.0747	0.0747	0.0747
Location (L)	0.0597	0.0597	0.0597
S·L	0.0752	0.0752	0.0752

Table 54. Continued

Taxon	Effect		S·L
	Sediment Source (S)	Location (L)	
Tendipedidae larvae	0.301	0.001*	0.656
<u>Tubificodes heterochaetus</u>	0.673	0.063	0.099
Unidentified gastropod	0.209	0.119	0.246
Unidentified leech ^(a)	0.468	0.356	0.506
Unidentified nemertean	0.624	0.093	1.000

Table 55. Null probabilities of MANOVA statistics testing for all hypotheses for macrobenthic recolonization data collected approximately nine months after the start of the experiment (May-June 1980)

Effect	Test Statistic		
	Hotelling-Lawley Trace	Pillai's Trace	Wilks' Criterion
Sediment source (S)	0.1272	0.1272	0.1272
Location (L)	0.0548	0.0548	0.0548
S·L	0.2632	0.2632	0.2632

Table 56. Null probabilities of F statistics of ANOVA's testing for all hypotheses for meiobenthic recolonization data collected between October 1979 and May 1980 (entire data set)

Taxon	Effect							
	Month (M)	Sediment Source (S)	Location (L)	M·L	S·L	M·S	M·S·L	Tray
<u>Acoela</u> sp. ^(a)	<0.001*	0.042*	<0.001*	0.037*	0.229	0.979	0.501	N/A
Amphipod juveniles	<0.001*	0.160	<0.001*	<0.001*	0.825	0.621	0.976	0.829
Barnacle cypris	0.001*	0.720	0.947	0.020*	0.329	0.356	0.212	0.920
Barnacle nauplius	0.411	0.329	0.353	0.425	0.357	0.422	0.448	0.451
Barnacle zoea	0.022*	0.056	0.045*	0.026*	0.071	0.019*	0.024*	0.981
Bivalve larvae	0.441	0.329	0.353	0.425	0.357	0.422	0.448	0.451
Bivalve juveniles	0.786	0.497	0.127	0.828	0.593	0.267	0.448	0.451
Calanoid copepods	0.001*	0.819	0.495	0.363	0.486	0.838	0.765	<0.001*
Calanoid nauplii	0.001*	0.411	0.080	0.014*	0.779	0.683	0.542	<0.001*
Ciliates	<0.001*	0.006*	<0.001*	<0.001*	0.170	0.146	0.181	0.673
Cladocerans	0.051*	0.088	0.811	0.995	0.976	0.052*	0.996	0.678
<u>Foraminifera</u> sp. 1	0.411	0.707	<0.001*	0.134	0.269	0.139	0.032*	0.731
<u>Foraminifera</u> sp. 2	0.441	0.329	0.303	0.458	0.294	0.464	0.448	<0.001*
<u>Harpacticoid</u> copepods ^(a)	<0.001*	0.604	<0.001*	0.061	0.089	0.564	1.000	N/A

* Effects that were significant at the 0.05 level.

^(a) Indicates taxa whose variances could not be homogenized by transformation and were not included in MANOVA analyses. Nonparametric ANOVA was used to test hypotheses concerning these taxa.

Table 56. Continued

Taxon	Effect							
	Month (M)	Sediment Source (S)	Location (L)	M·L	S·L	M·S	M·S·L	Tray
Hydrozoans	0.015*	0.374	0.049*	0.014*	0.402	0.504	0.530	0.900
Isopod juveniles	0.441	0.329	0.303	0.458	0.357	0.422	0.448	0.451
Nematodes ^(a)	0.002*	0.733	<0.001*	0.281	1.000	0.650	1.000	N/A
<u>Nereis</u> larvae and juveniles	<0.001*	0.191	0.006*	<0.001*	0.465	0.559	0.386	<0.001*
Oligochaetes	<0.001*	0.082	<0.001*	0.314	0.301	0.203	0.336	<0.001*
Ostracods ^(a)	0.271	0.733	<0.001*	1.000	0.291	0.808	0.988	N/A
Polychaete larvae	<0.001*	0.784	<0.001*	<0.001*	0.665	0.738	0.104	0.052*
Rotifers	<0.001*	0.322	0.807	0.784	0.683	0.140	0.372	<0.001*
Tendipedidae larvae	<0.001*	0.674	<0.001*	<0.001*	0.492	0.025*	0.011*	0.024*
Tardigrades	0.002*	0.552	0.044*	0.007*	0.825	0.947	0.994	<0.001*
Unidentified flatworms	0.441	0.329	0.303	0.458	0.357	0.422	0.448	<0.001*

Table 57. Null probabilities of MANOVA statistics listing all hypotheses for meiobenthic recolonization data collected between October 1979 and May 1980 (entire month set)

Effect	Test Statistic		
	Hotelling-Lawley Trace	Pillai's Trace	Wilks' Criterion
Month (M)	0.0001*	0.0001*	0.0001*
Sediment source (S)	0.2728	0.2728	0.2728
Location (L)	0.0001*	0.0001*	0.0001*
M·L	0.0001*	0.0004*	0.0001*
S·L	0.9173	0.9173	0.9173
M·S	0.0065	0.0786	0.0244*
M·S·L	0.1658	0.2635	0.1732
Tray	0.0001*	0.0001*	0.0001*

* Effects that were significant at the 0.05 level.

Table 58. Null probabilities of F statistics of ANOVA's testing all hypotheses for meiobenthic recolonization data collected approximately one month after the start of the experiment (October 1979)

Taxon	Effect			
	Sediment Source (S)	Location (L)	S·L	Tray
<u>Acoela</u> sp. ^(a)	0.502	0.001*	0.180	N/A
Amphipod juveniles	0.667	0.217	0.667	0.461
Barnacle cypris	0.347	0.347	0.347	0.461
Bivalve juveniles	0.347	0.347	0.347	0.461
Bivalve larvae	0.347	0.347	0.347	0.347
Calanoid copepods	0.347	0.347	0.347	0.461
Calanoid nauplii	0.150	0.035*	0.121	0.295
Ciliates	0.013*	0.003*	0.008*	0.587
<u>Foraminifera</u> sp.1 ^(a)	0.113	0.023*	0.113	0.747
<u>Foraminifera</u> sp.2 ^(b)	0.347	0.347	0.347	0.007*
Harpacticoid copepods ^(a)	0.505	0.008*	0.182	N/A
Hydrozoans	0.390	0.068	0.390	0.731
Isopod juveniles	0.347	0.347	0.347	0.461
Nematodes ^(a)	0.505	<0.001*	0.505	N/A

* Effects that were significant at the 0.05 level.

(a) Species used in MANOVA as determined by criteria discussed in Analysis section.

(b) Species distribution could not be suitably transformed for parametric statistical analyses. Experimental univariate effects were tested for using "Wilson's" nonparametric analysis of variance. Species was not included in MANOVA analysis.

Table 58. Continued

Taxon	Sediment Source (S)	Effect		Tray
		Location (L)	S.L	
Nereis larvae and juveniles	0.347	0.347	0.347	0.461
Oligochaetes	0.567	0.002*	0.687	0.112
Ostracods ^(a)	1.000	<0.001*	1.000	N/A
Polychaete larvae	0.580	0.580	0.580	0.461
Rotifers	0.347	0.347	0.347	0.461
Tendipedidae larvae	0.077	0.003*	0.077	0.079
Unidentified flatworm	0.347	0.347	0.347	0.004*

Table 59. Null probabilities of MANOVA statistics testing all hypotheses for meiobenthic recolonization data collected approximately one month after the start of the experiment (October 1979)

Effect	Test Statistic		
	Hotelling-Lawley Trace	Pillai's Trace	Wilks' Criterion
Sediment source (S)	0.413	0.413	0.413
Location (L)	0.374	0.374	0.374
S·L	0.277	0.277	0.277
Tray	0.291	0.196	0.218

Table 60. Null probabilities of F statistics of ANOVA's testing hypotheses for meiobenthic recolonization data collected approximately three months after the start of the experiment (December 1979-January 1980)

Taxon	Effect		S·L	Tray
	Sediment Source (S)	Location (L)		
<u>Acoela</u> sp. ^(a)	0.505	<0.001*	1.000	N/A
Barnacle cypris	0.783	0.203	0.783	0.461
Bivalve juveniles	0.347	0.347	0.347	0.461
Calanoid nauplii	0.595	0.007*	0.961	0.026*
Ciliates	0.001*	<0.001*	0.017*	0.846
<u>Foraminifera</u> sp. 1 ^(a)	0.240	0.010*	0.240	0.483
Harpacticoid copepods ^(a)	0.505	<0.001*	1.000	N/A
Nematodes ^(a)	0.505	<0.001*	1.000	N/A
Oligochaetes	0.114	0.001*	0.491	0.003*
Ostracods ^(a)	1.000	<0.001*	0.182	N/A
Polychaete larvae	0.206	<0.001*	0.206	0.335
Rotifers	0.397	0.783	0.952	<0.001*
Tendipedidae larvae	0.850	0.477	0.477	0.462

* Effects that were significant at the 0.05 level.

(a) Indicates species whose variances could not be homogenized by transformation and were not included in MANOVA analyses. Nonparametric ANOVA was used to test hypotheses concerning these species.

Table 61. Null probabilities of MANOVA statistics testing all hypotheses for meiobenthic recolonization data collected approximately three months after the start of the experiment (December 1979-January 1980)

Effect	Test Statistic		
	Hotelling-Lawley Trace	Pillai's Trace	Wilks' Criterion
Sediment source (S)	0.0610	0.0610	0.0610
Location (L)	0.0083*	0.0083*	0.0083*
S·L	0.0612	0.0612	0.0612
Tray	0.0001*	0.0203*	0.0001*

* Effects that were significant at the 0.05 level.

Table 62. Null probabilities of F statistics of ANOVA's testing for hypotheses for meiobenthic recolonization data collected approximately six months after the start of the experiment (February-March 1980)

Taxon	Effect		S-L	Tray
	Sediment Source (S)	Location (L)		
<u>Acoela</u> sp. ^(a)	0.505	<0.001*	0.505	N/A
Barnacle nauplius	0.347	0.347	0.347	0.461
Barnacle zoea	0.081	0.081	0.081	0.844
Calanoid copepods	0.618	0.351	0.520	<0.001*
Calanoid nauplii	0.668	0.625	0.721	<0.001*
Ciliates	0.607	0.041*	0.972	0.286
Cladocerans	0.114	0.885	0.885	0.579
<u>Formaminiifera</u> sp.1 ^(a)	0.887	0.039*	0.136	0.154
Harpacticoid copepods ^(a)	0.182	0.008*	0.045*	N/A
Nematodes ^(a)	1.000	<0.001*	0.505	N/A
Oligochaetes	0.976	0.007*	0.245	0.001*
Ostracods ^(a)	1.000	0.001*	0.182	N/A
Polychaete larvae	0.820	0.003*	0.109	0.327
Rotifers	0.406	0.595	0.791	0.005*
Tardigrades	0.724	0.051*	0.956	0.036*
Tendipedidae larvae	0.694	0.256	0.694	0.209

* Effects that were significant at the 0.05 level.

(a) Indicates taxa whose variances could not be homogenized by transformation and were not included in MANOVA analyses. Nonparametric ANOVA was used to test hypotheses concerning these taxa.

Table 63. Null probabilities of MANOVA statistics testing for all hypotheses for meiobenthic recolonization data collected approximately six months after the start of the experiment (February-March 1980)

Effect	Test Statistic		
	Hotelling-Lawley Trace	Pillai's Trace	Wilks' Criterion
Sediment source (S)	0.5565	0.5565	0.5565
Location (L)	0.0978	0.0978	0.0978
S·L	0.3184	0.3184	0.3184
Tray	0.0001*	0.0456*	0.0022*

* Effects that were significant at the 0.05 level.

Table 64. Null probabilities for F statistics of ANOVA's testing for hypothesis for meiobenthic recolonization data collected approximately nine months after the start of the experiment (May-June 1980)

Taxon	Effect			
	Sediment Source (S)	Location (L)	S·L	Tray(s)
<u>Acoela</u> sp. ^(a)	0.095	0.317	0.317	N/A
Amphipod juveniles	0.227	<0.001*	0.819	0.613
Barnacle cypris	0.479	0.084	0.204	0.813
Bivalve juveniles	0.468	0.356	0.506	0.391
Calanoid copepods	0.520	0.456	0.871	0.406
Calanoid nauplii	0.109	0.042*	0.123	0.125
Ciliates	0.613	0.009*	0.429	0.734
<u>Foraminifera</u> sp.1 ^(a)	0.393	0.864	0.014*	0.981
Harpacticoid copepods ^(a)	0.505	0.182	0.182	N/A
Nematodes ^(a)	0.008*	0.046*	0.182	N/A
<u>Nereis</u> larvae and juveniles	0.217	0.034*	0.406	<0.001*
Oligochaetes	0.100	0.025*	0.237	0.040*
Ostracods ^(a)	0.182	0.046*	0.008*	N/A
Polychaete larvae	0.806	0.011*	0.814	0.020*
Rotifers	0.003*	0.030*	0.003*	0.245
Tardigrades	0.289	0.635	0.506	0.391
Tendipedidae larvae	0.025*	0.001*	0.120	0.166

* Effects that were significant at the 0.05 level.

(a) Indicates taxa whose variances could not be homogenized by transformation and were not included in MANOVA analyses. Nonparametric ANOVA was used to test hypotheses concerning these taxa.

Table 65. Null probability for MANOVA statistics testing for all hypotheses for meiobenthic recolonization data collected approximately nine months after the start of the experiment (May-June 1980)

Effect	Test Statistic		
	Hotelling-Lawley Trace	Pillai's Trace	Wilks' Criterion
Sediment source (S)	0.1722	0.1722	0.1722
Location (L)	0.0421*	0.0421*	0.0421*
S·L	0.1336	0.1336	0.1336
Tray	0.0734	0.1606	0.0885

* Effects that were significant at the 0.05 level.

Table 66. Summary of data (number per m²) on macrobenthic organisms at the caged area that was organically enriched in 1979-1980

Taxon	September	October	March	May
<u>Corophium</u> sp.	0	0.75 \pm 0.96	5.75 \pm 2.50	2.25 \pm 1.71
<u>Cyathura</u> <u>polita</u>	5.75 \pm 5.44	3.25 \pm 2.22	2.50 \pm 2.38	4.50 \pm 4.65
<u>Heteromastus</u> <u>filiformis</u>	3.25 \pm 2.63	3.00 \pm 3.56	4.75 \pm 2.97	4.75 \pm 3.20
<u>Hypaniola</u> <u>grayi</u>	0	3.00 \pm 6.00	0.25 \pm 0.50	9.50 \pm 5.45
<u>Leptocheirus</u> <u>plumulosus</u>	0.25 \pm 0.50	0.50 \pm 1.00	0.75 \pm 1.50	35.00 \pm 24.70
<u>Limnodrilus</u> <u>hoffmeisteri</u>	4.75 \pm 2.22	3.50 \pm 3.11	1.25 \pm 0.96	4.25 \pm 4.66
<u>Macoma</u> <u>balthica</u>	3.00 \pm 3.46	2.00 \pm 1.41	1.00 \pm 0.82	0.50 \pm 0.58
<u>Macoma</u> <u>phenax</u>	0.75 \pm 0.50	1.00 \pm 1.41	1.25 \pm 1.26	2.25 \pm 2.63
Nemerteans (unidentified)	1.00 \pm 0.82	2.50 \pm 0.58	2.50 \pm 0.58	2.00 \pm 1.15
<u>Nereis</u> <u>succinea</u>	2.50 \pm 1.92	4.50 \pm 1.73	1.75 \pm 1.26	0.75 \pm 0.50
<u>Scolecoides</u> <u>viridis</u>	2.50 \pm 2.08	0.75 \pm 0.96	22.25 \pm 4.27	52.50 \pm 38.49
Tendipedidae larvae	0	0	0.50 \pm 0.58	43.75 \pm 22.02
<u>Tubificoides</u> <u>heterochaetus</u>	33.50 \pm 25.80	21.50 \pm 18.45	11.00 \pm 7.87	19.25 \pm 2.99

Table 67. Null probabilities of F statistics of ANOVA's testing for station differences (i.e., probability of no effect from organic enrichment) for macrobenthic data collected at the start of the experiment (September) and at one (October), six (March), and nine (May) months after the start of the experiment. The two stations used in the analysis were a caged and organically enriched area and an uncaged adjacent reference area

Taxon	September	October	March	May
<u>Corophium</u> sp.	--	0.150	0.005*	0.849
<u>Cyathura</u> <u>polita</u>	0.413	0.788	0.137	0.184
<u>Heteromastus</u> <u>filiformis</u>	0.100	0.421	0.672	0.111
<u>Hypaniola</u> <u>grayi</u>	--	0.978	1.000	<0.001*
<u>Leptocheirus</u> <u>plumulosus</u>	0.537	0.356	0.418	0.181
<u>Limnodrilus</u> <u>hoffmeisteri</u>	0.385	0.835	0.295	0.544
<u>Macoma</u> <u>balthica</u>	0.340	0.560	0.779	0.008*
<u>Macoma</u> <u>phenax</u>	0.736	1.000	0.850	0.227
Nemerteans (unidentified)	0.312	0.305	0.334	0.664
<u>Nereis</u> <u>succinea</u>	0.896	0.683	0.907	0.005*
<u>Scolecoides</u> <u>viridis</u>	0.665	0.277	0.672	0.839
Tendipedidae larvae	--	0.356	0.134	<0.001*
<u>Tubificoides</u> <u>heterochaetus</u>	0.407	0.428	0.831	0.005*

* Significant ($P < 0.05$) station differences were detected.

-- Species were not present during sampling period.

Table 68. Null probabilities of MANOVA statistics testing for station differences (i.e., probability of no effect from organic enrichment) in macrobenthic community structure for macrobenthic data collected at the start of the experiment (September) and at one (October), six (March), and nine (May) months after the start of the experiment. The two stations used in the analysis were a caged and organically enriched area and an uncaged reference area

Test Statistic	September	October	March	May
Hotelling-Lawley Trace	0.367	0.073	0.153	0.003*
Pillai's Trace	0.367	0.073	0.153	0.003*
Wilks' Criterion	0.367	0.073	0.153	0.003*

* Significant ($P < 0.05$) station differences were detected.

Table 69. Null probabilities of F statistics of ANOVA's testing for station differences (i.e., probability of no difference) for macrobenthic data collected at the start of the experiment (September) and at one (October), six (March), and nine (May) months after the start of the experiment. The two stations used in the analysis were a caged and organically enriched area and a control caged area.

Taxon	September	October	March	May
<u>Corophium</u> sp.	--	0.150	0.696	0.406
<u>Cyathura</u> <u>polita</u>	0.413	0.751	0.193	0.416
<u>Heteromastus</u> <u>filiformis</u>	0.100	0.759	0.766	0.058
<u>Hypaniola</u> <u>grayi</u>	0.134	0.508	0.537	0.527
<u>Leptocheirus</u> <u>plumulosus</u>	0.537	0.839	0.730	0.900
<u>Limnodrilus</u> <u>hoffmeisteri</u>	0.385	0.837	0.580	0.151
<u>Macoma</u> <u>balthica</u>	0.340	0.062	0.400	0.093
<u>Macoma</u> <u>phenax</u>	0.736	0.390	1.000	0.886
Nemerteans (unidentified)	0.316	0.656	0.731	0.316
<u>Nereis</u> <u>succinea</u>	0.896	0.068	0.890	0.040*
<u>Scolecoides</u> <u>viridis</u>	0.750	0.007*	0.121	0.349
Tendipedidae larvae	--	--	1.000	0.101
<u>Tubificoides</u> <u>heterochaetus</u>	0.407	0.606	0.094	0.007*

* Significant ($P < 0.05$) station effects were detected.

-- Species not present during sampling period.

Table 70. Null probabilities of MANOVA statistics testing for station differences (i.e., probability of no difference) in macrobenthic community structure for macrobenthic data collected at the start of the experiment (September) and one (October), six (March), and nine (May) months after the start. The two stations used in the analysis were a caged and organically enriched area and a control caged area.

Test Statistic	September	October	March	May
Hotelling-Lawley Trace	0.369	<0.001*	0.182	0.466
Pillai's Trace	0.369	<0.001*	0.182	0.466
Wilks' Criterion	0.369	<0.001*	0.182	0.466

* Significant ($P < 0.05$) station differences were detected.

Table 71. Null probabilities of F statistics of ANOVA's testing for all hypotheses for macrobenthic abundance data collected between September 1979 and May 1980 (entire data set) at a caged and organically enriched area and an uncaged reference area

Taxon	Station (S)	Effect	
		Month (M)	S·M
<u>Corophium</u> sp.	0.007*	<0.001*	0.025*
<u>Cyathura</u> <u>polita</u>	0.446	0.037*	0.201
<u>Heteromastus</u> <u>filiformis</u>	0.040*	0.314	0.386
<u>Hypaniola</u> <u>grayi</u>	0.007*	0.002*	0.001*
<u>Leptocheirus</u> <u>plumulosus</u>	0.232	0.001*	0.366
<u>Limnodrilus</u> <u>hoffmeisteri</u>	0.625	0.011*	0.701
<u>Macoma</u> <u>balthica</u>	0.882	0.856	0.099
<u>Macoma</u> <u>phenax</u>	0.050*	0.971	0.565
Nemerteans (Unidentified)	0.831	0.465	0.335
<u>Nereis</u> <u>succinea</u>	0.410	0.234	0.307
<u>Scolecoides</u> <u>viridis</u>	0.478	<0.001*	0.879
Tendipedidae larvae	<0.001*	<0.001*	<0.001*
<u>Tubificoides</u> <u>heterochaetus</u>	0.531	0.046*	0.452

* Effects that were significant at the 0.05 level.

Table 72. Null probabilities of MANOVA statistics testing for station differences in macrobenthic abundance data collected between September 1979 and May 1980 (entire data set) at a caged and organically enriched area and at an adjacent uncaged reference area

Effect	Test Statistic		
	Hotelling-Lawley Trace	Pillai's Trace	Wilks' Criterion
Station (S)	0.015*	0.015*	0.015*
Month (M)	<0.001*	<0.001*	<0.001*
S·M	0.001*	0.001*	0.001*

* Effects that were significant at the 0.05 level.

Table 73. Null probabilities of F statistics of ANOVA's testing for all hypotheses for macrobenthic abundance data collected between September 1979 and May 1980 (entire data set) at a caged and organically enriched area and at an adjacent control caged area

Taxon	Station (S)	Effect	S·M
		Month (M)	
<u>Corophium</u> sp.	0.930	<0.001*	0.302
<u>Cyathura</u> <u>polita</u>	0.182	0.333	0.760
<u>Heteromastus</u> <u>filiformis</u>	0.159	0.058	0.204
<u>Hypaniola</u> <u>grayi</u>	0.921	<0.001*	0.315
<u>Leptocheirus</u> <u>plumulosus</u>	0.534	<0.001*	0.994
<u>Limnodrilus</u> <u>hoffmeisteri</u>	0.205	0.043*	0.564
<u>Macoma</u> <u>balthica</u>	0.154	0.628	0.154
<u>Macoma</u> <u>phenax</u>	0.794	0.111	0.788
Nemerteans (unidentified)	0.155	0.367	0.930
<u>Nereis</u> <u>succinea</u>	0.738	0.703	0.060
<u>Scolecopides</u> <u>viridis</u>	0.131	<0.001*	0.549
Tendipedidae larvae	0.085	<0.001*	0.040*
<u>Tubificodes</u> <u>heterochaetus</u>	0.096	0.071	0.225

* Effects that were significant at the 0.05 level.

Table 74. Null probabilities of MANOVA statistics testing for station differences in macrobenthic abundance data collected between September 1979 and May 1980 (entire data set) at a caged and organically enriched area and at an adjacent control caged area

Effect	Test Statistic		
	Hotelling-Lawley Trace	Pillai's Trace	Wilks' Criterion
Station (S)	0.270	0.270	0.270
Month (M)	<0.001*	<0.001*	<0.001*
S·M	0.380	0.460	0.406

* Effects that were significant at the 0.05 level.

VIII. FIGURES

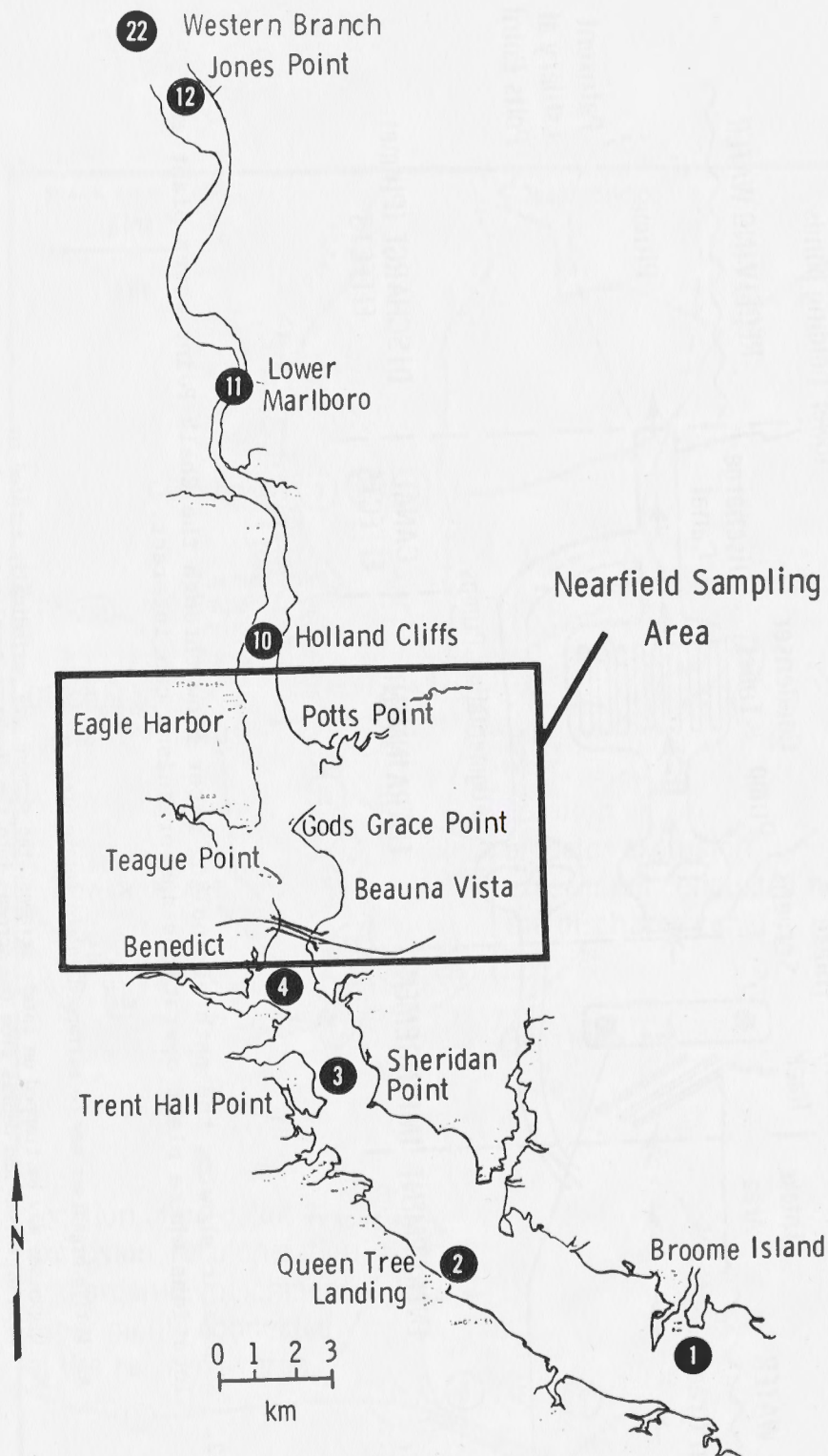


Figure 1. Map of the Patuxent estuary showing farfield sampling stations.

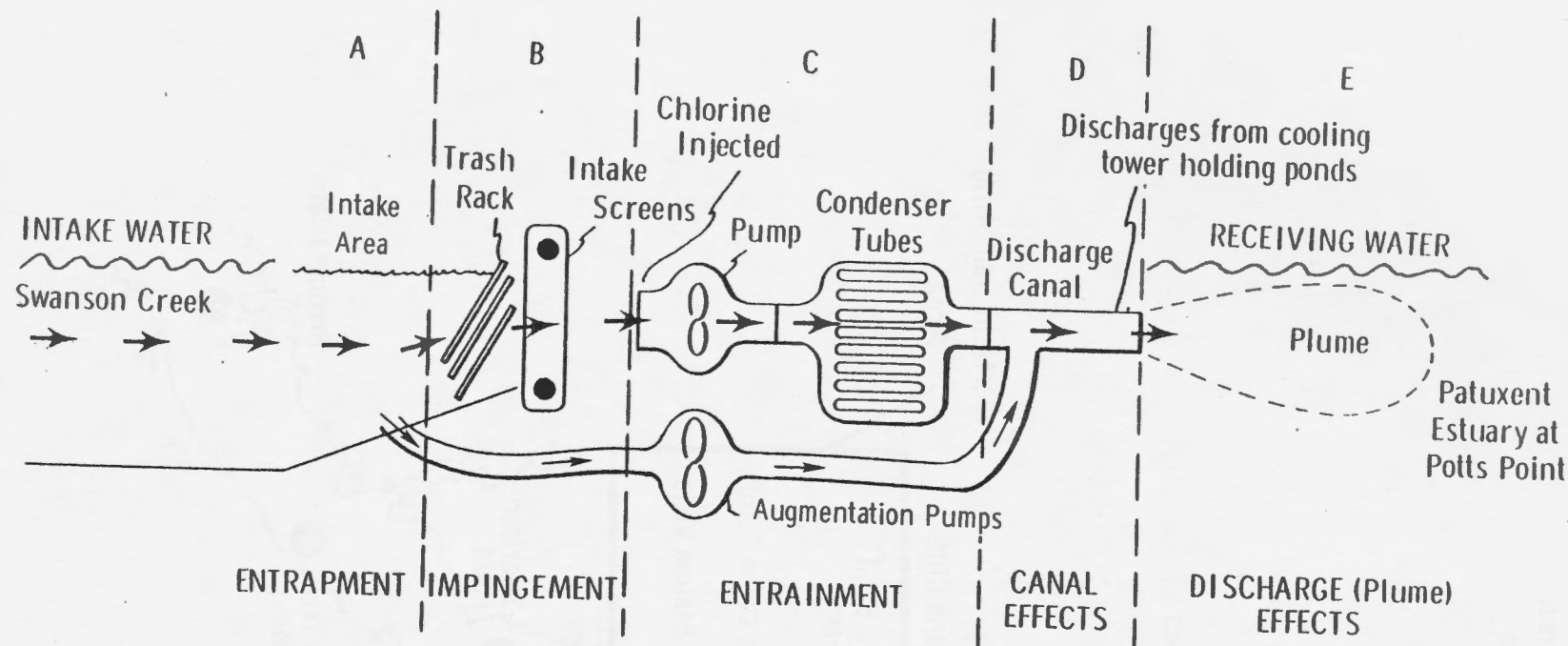


Figure 2. Schematic showing the path of cooling water flow through the Chalk Point power plant and locations where plant operations and organisms can interact.

- A. Motile organisms may be entrapped in the intake area.
- B. Organisms may be trapped on intake screens; the screens are periodically rotated to wash organisms and debris from the screens into the discharge canal via a trough.
- C. Small organisms in the water column pass through the cooling system; they experience a temperature rise and shear and pressure forces during their transit through the cooling system and are exposed to lethal levels of chlorine and its residue during warm months.
- D. Organisms surviving entrainment and impingement are exposed to excess temperatures and high levels of chlorine during transit down the discharge canal on route back to the receiving body.
- E. Organisms in the receiving water may encounter temperature rises and potentially stressful chemical substances in the discharge plume.

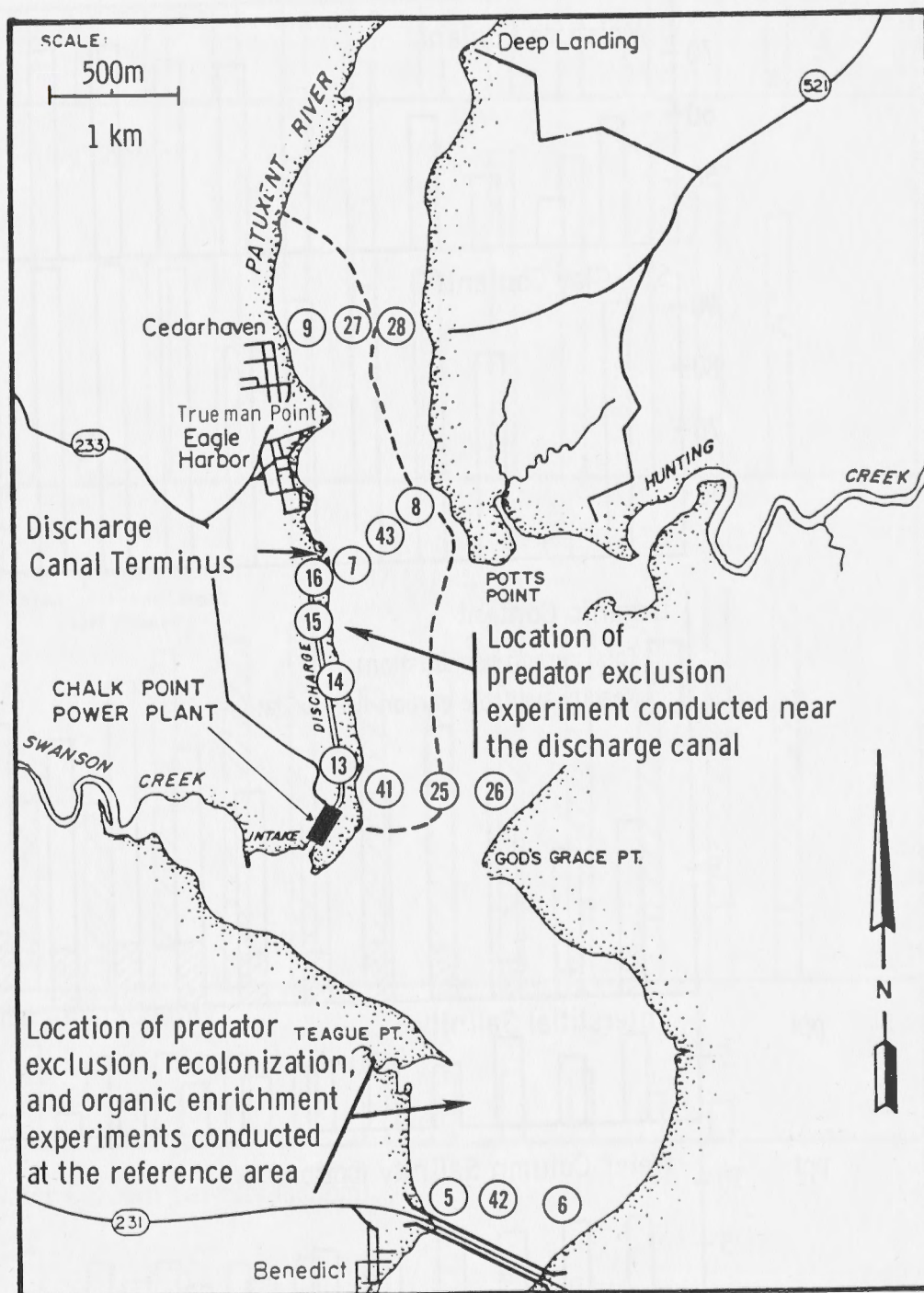


Figure 3. Locations of nearfield sampling stations. Dashed lines indicate bottom habitats touched by discharge waters that are 2°C or more above ambient water temperatures.

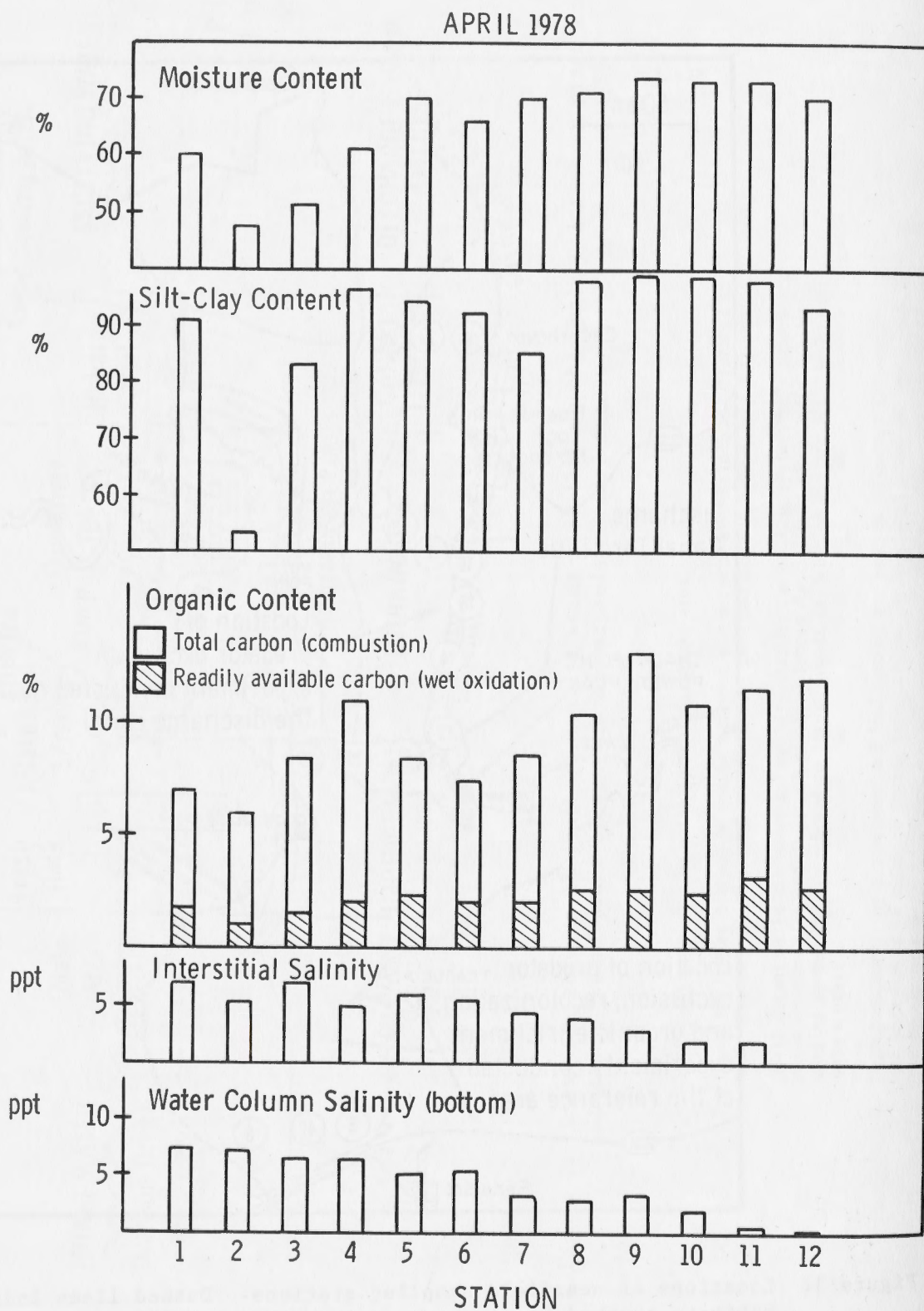


Figure 4. Physical characteristics of the sediments and water column for benthic sampling stations during the comprehensive survey in April 1978.

OCTOBER 1978

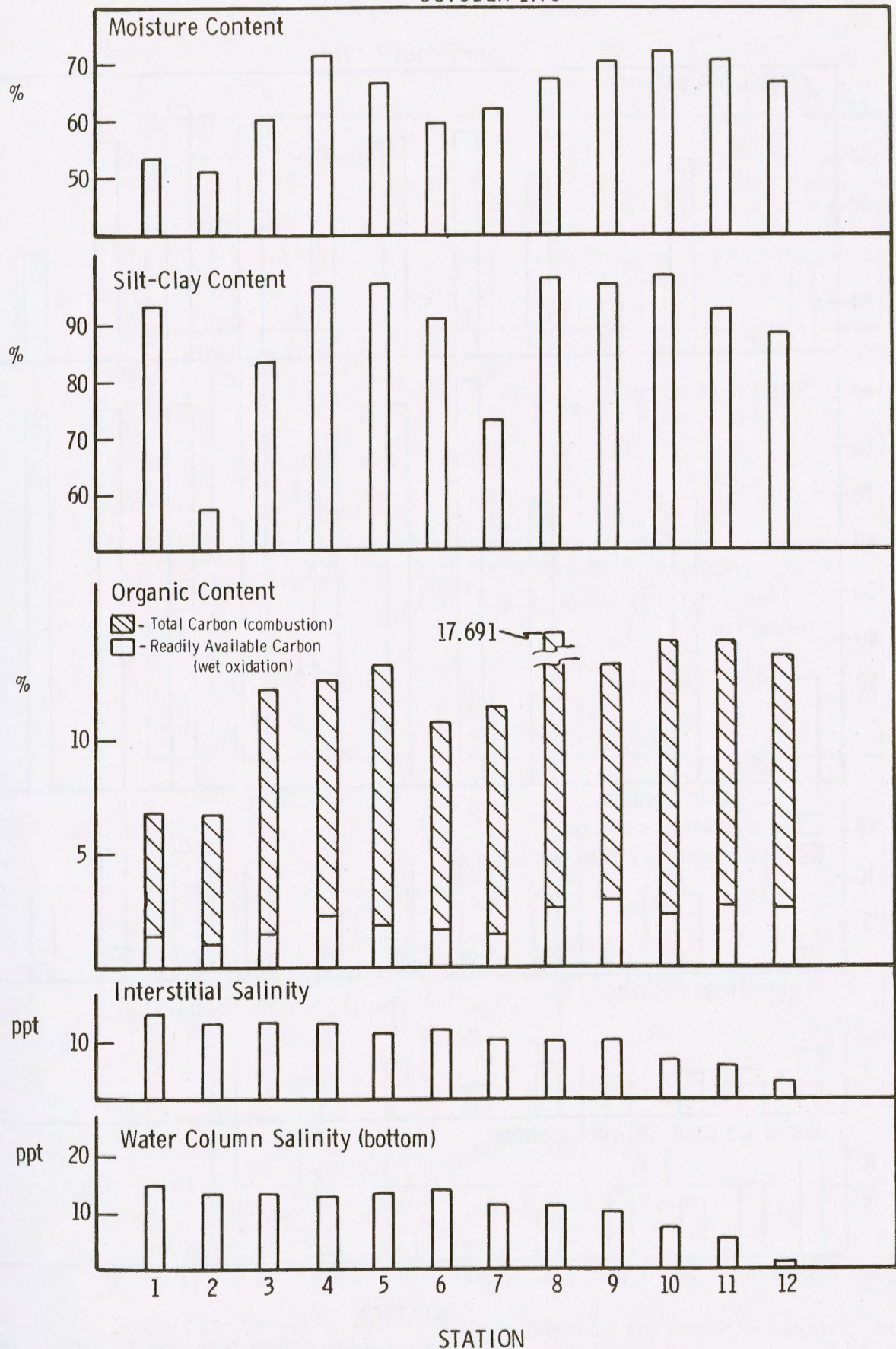


Figure 5. Physical characteristics of the sediments and water column for benthic sampling stations during the comprehensive survey in October 1978.

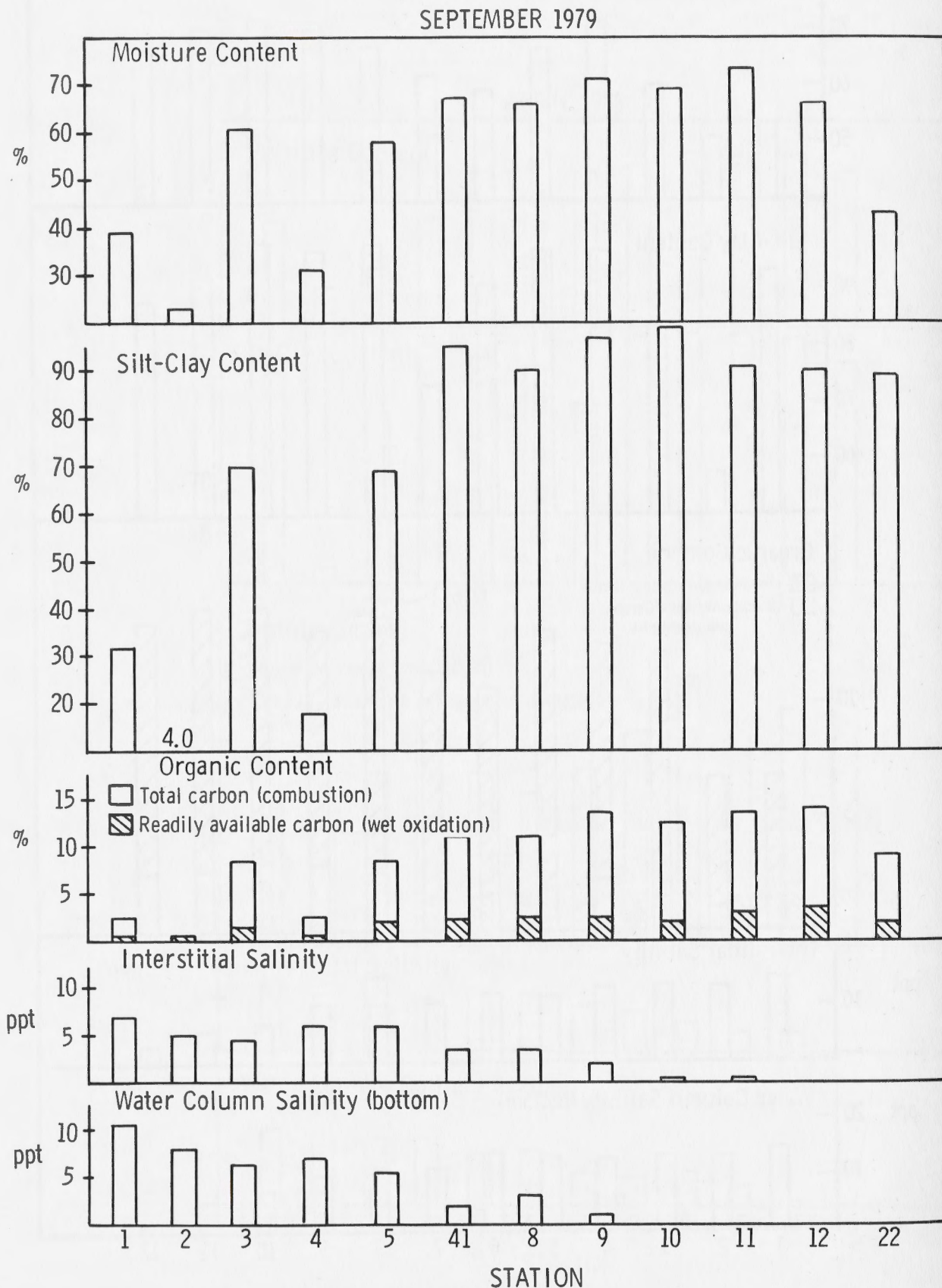


Figure 6. Physical characteristics of the sediments and water column for benthic sampling stations during the comprehensive survey in September 1979.

STATION 3

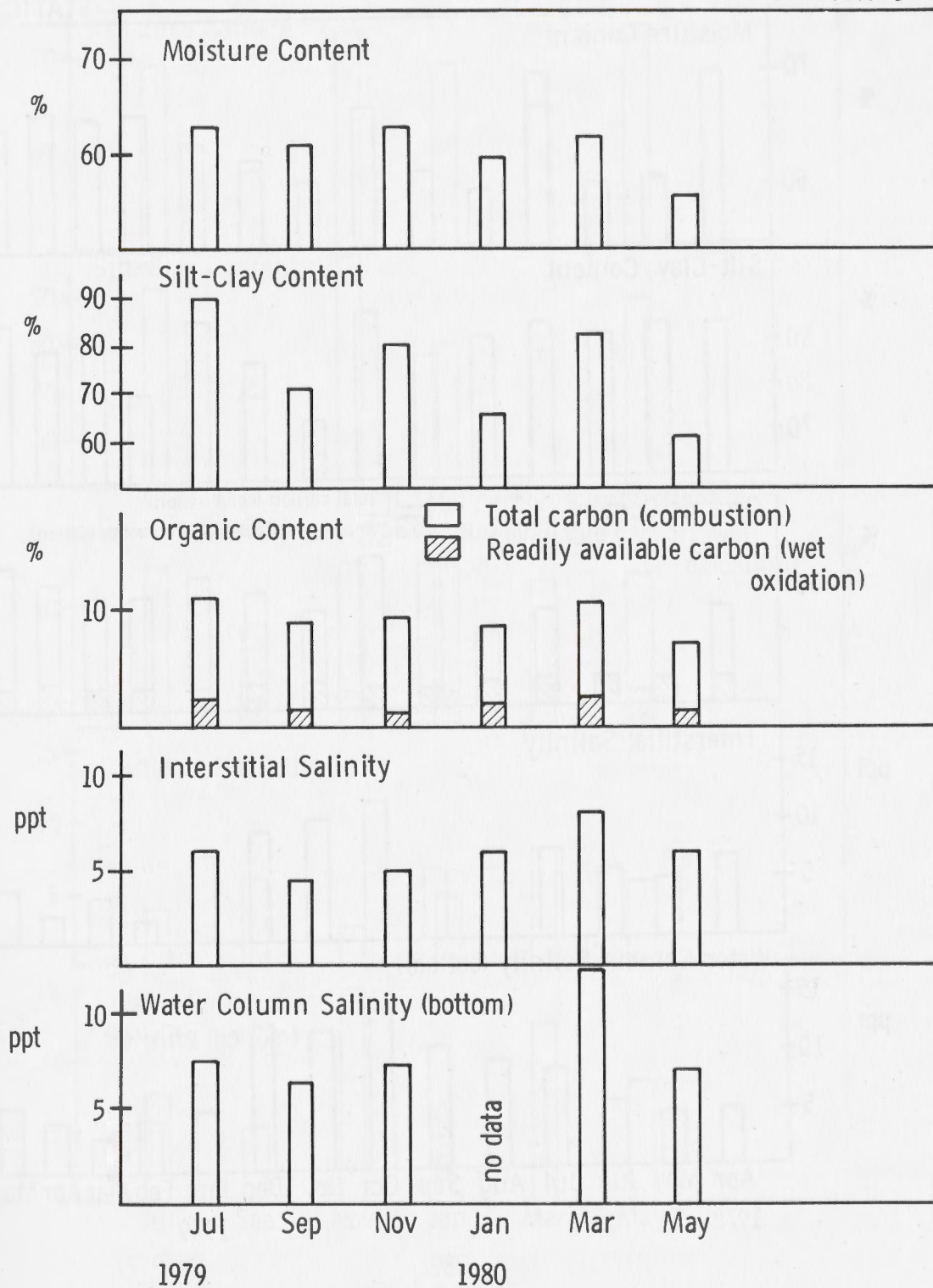


Figure 7. Physical characteristics of the sediments and water column for station 3 from July 1979 through May 1980.

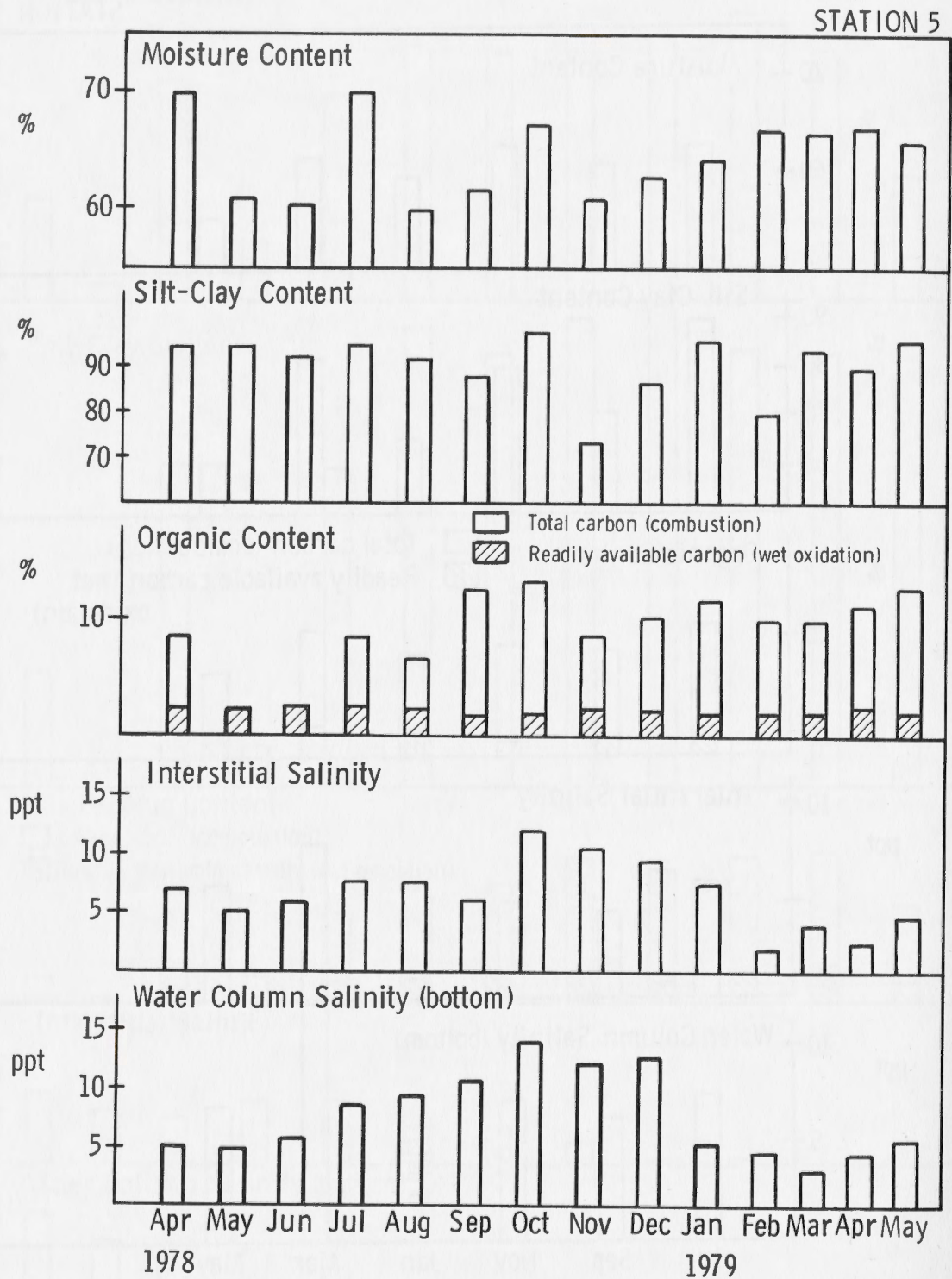


Figure 8. Physical characteristics of the sediments and water column for station 5 from April 1978 through May 1979.

STATION 5

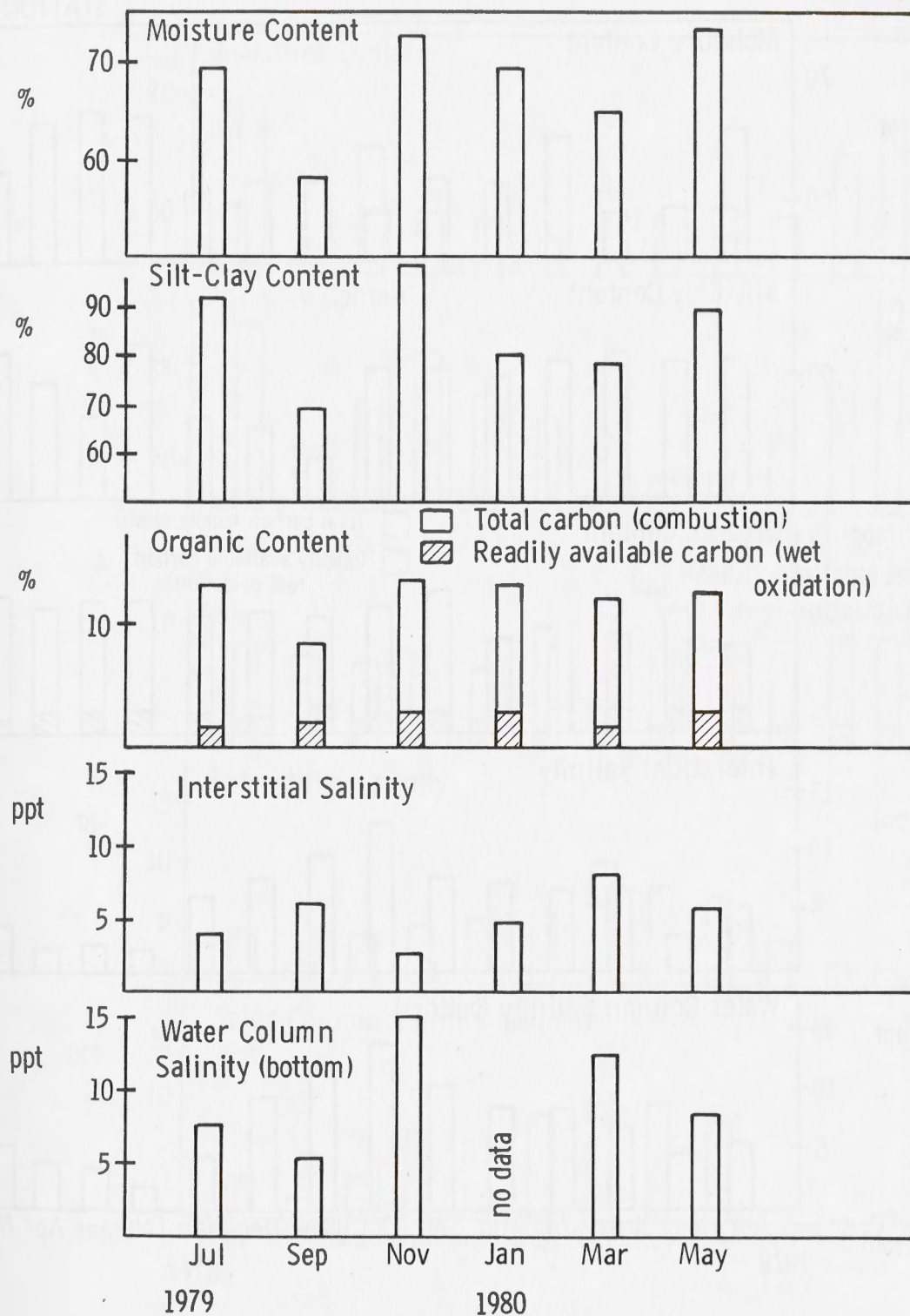


Figure 9. Physical characteristics of the sediments and water column for station 5 from July 1979 through May 1980.

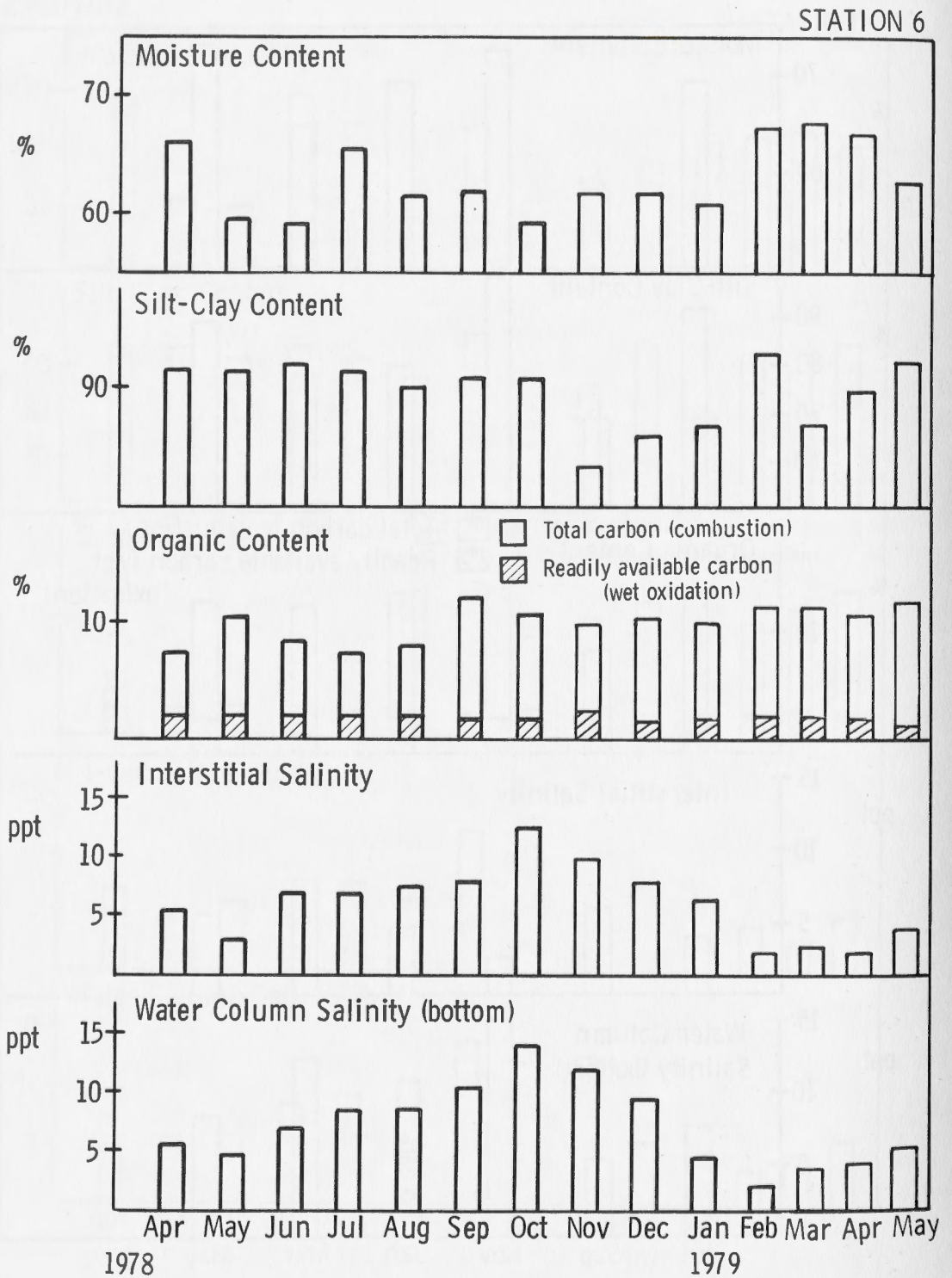


Figure 10. Physical characteristics of the sediments and water column for station 6 from April 1978 through May 1979.

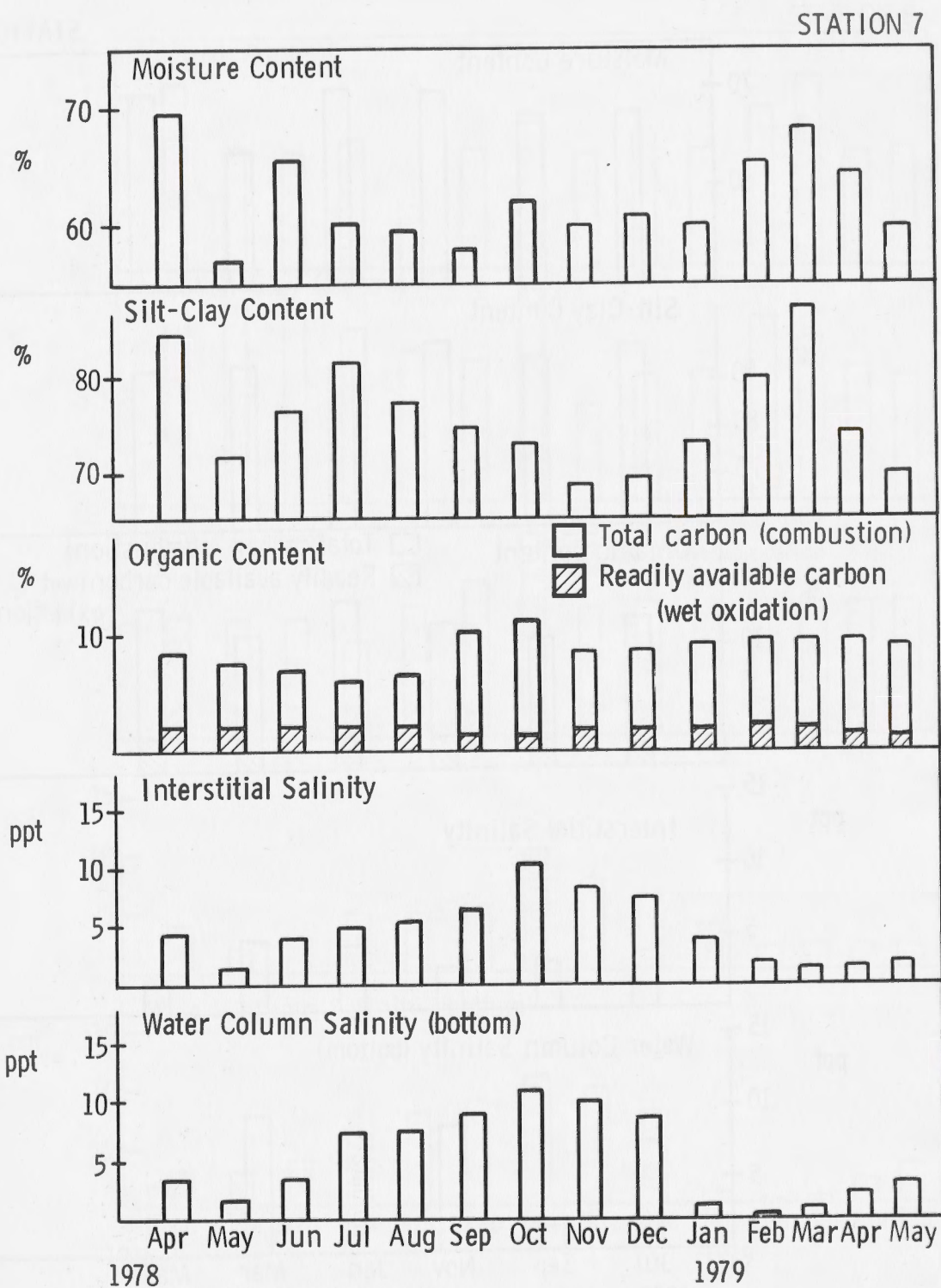


Figure 11. Physical characteristics of the sediments and water column for station 7 from April 1978 through May 1979.

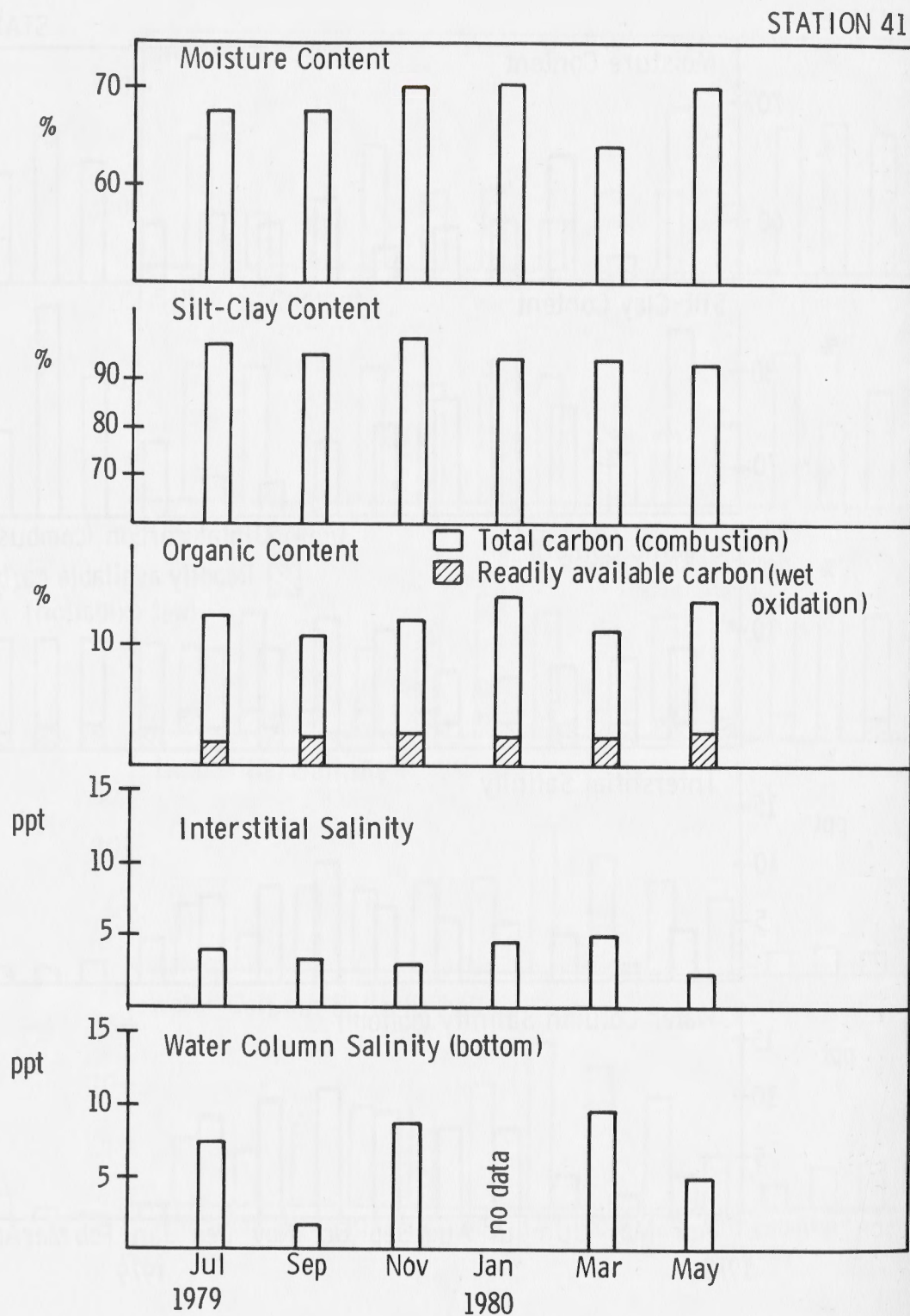


Figure 12. Physical characteristics of the sediments and water column for station 41 from July 1979 through May 1980.

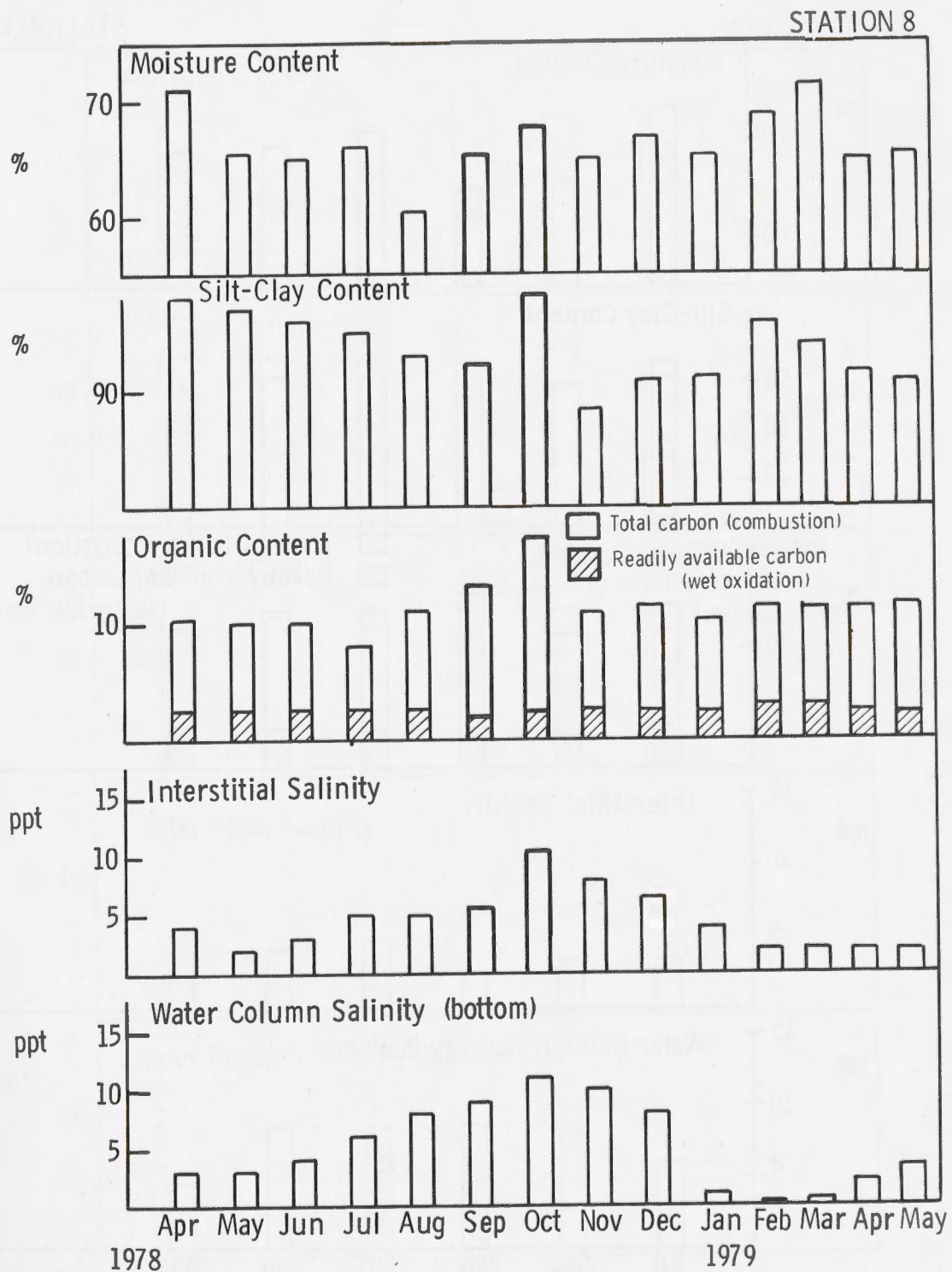


Figure 13. Physical characteristics of the sediments and water column for station 8 from April 1978 through May 1979.

STATION 8

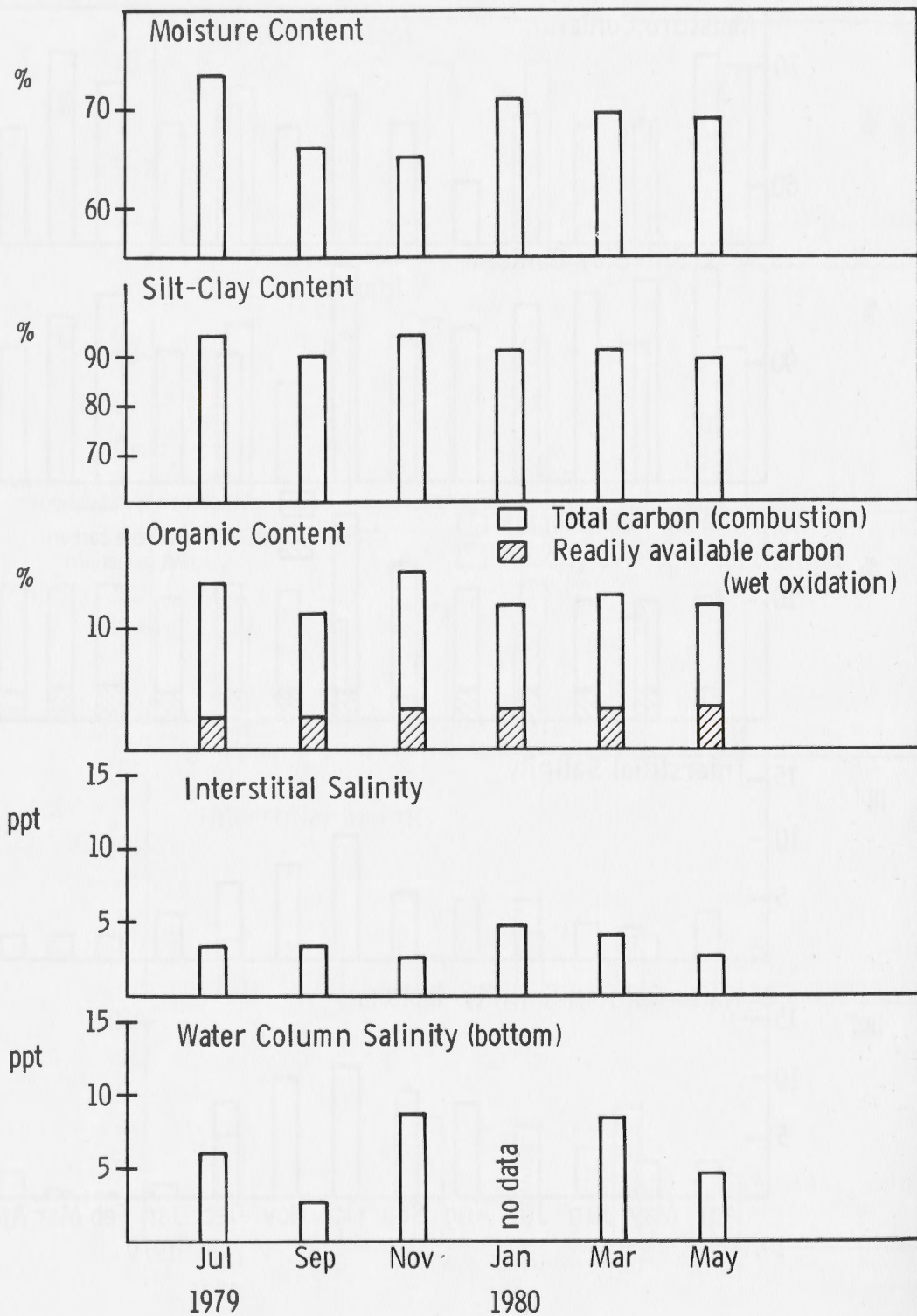


Figure 14. Physical characteristics of the sediments and water column for station 8 from July 1979 through May 1980.

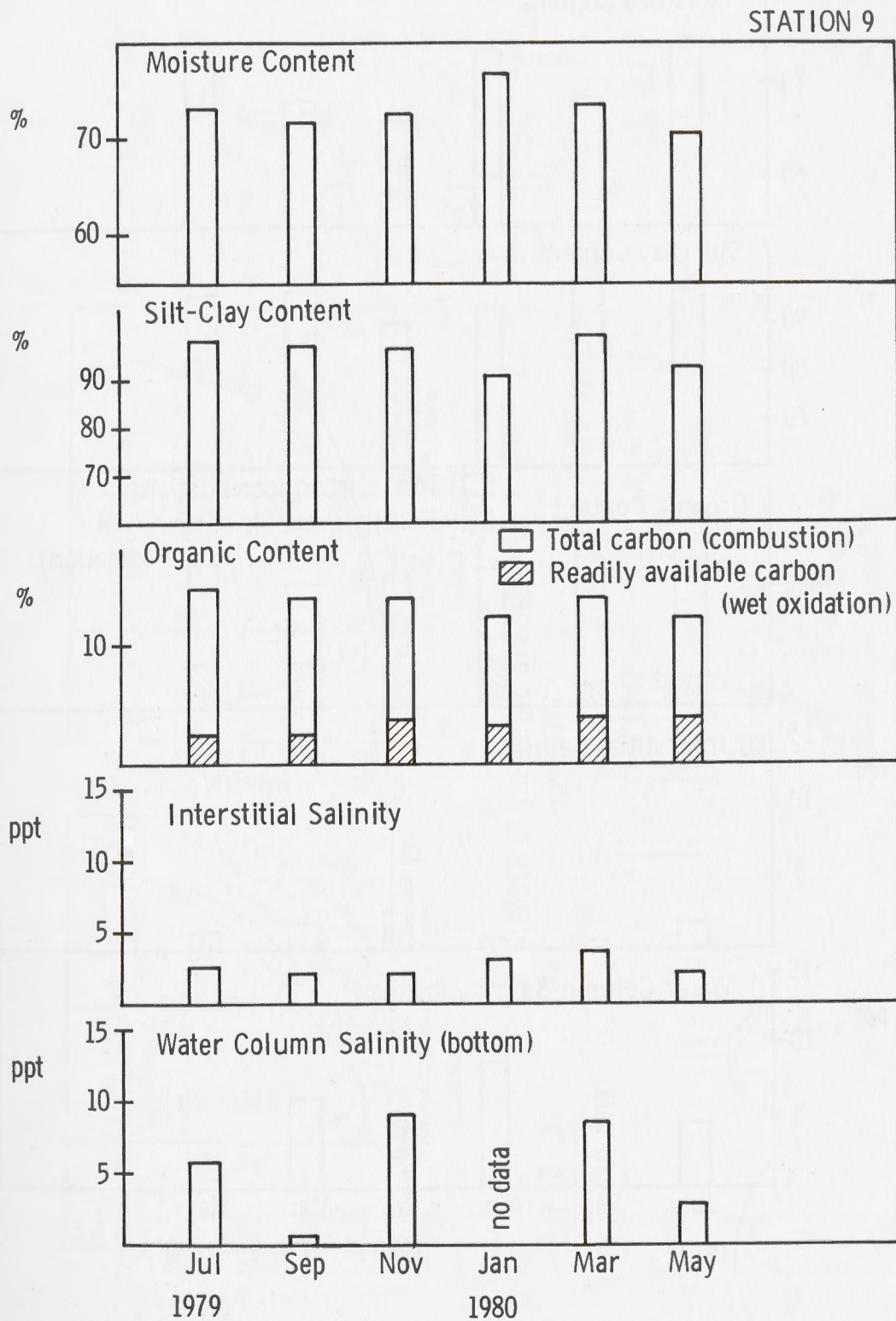


Figure 15. Physical characteristics of the sediments and water column for station 9 from July 1979 through May 1980.

STATION 10

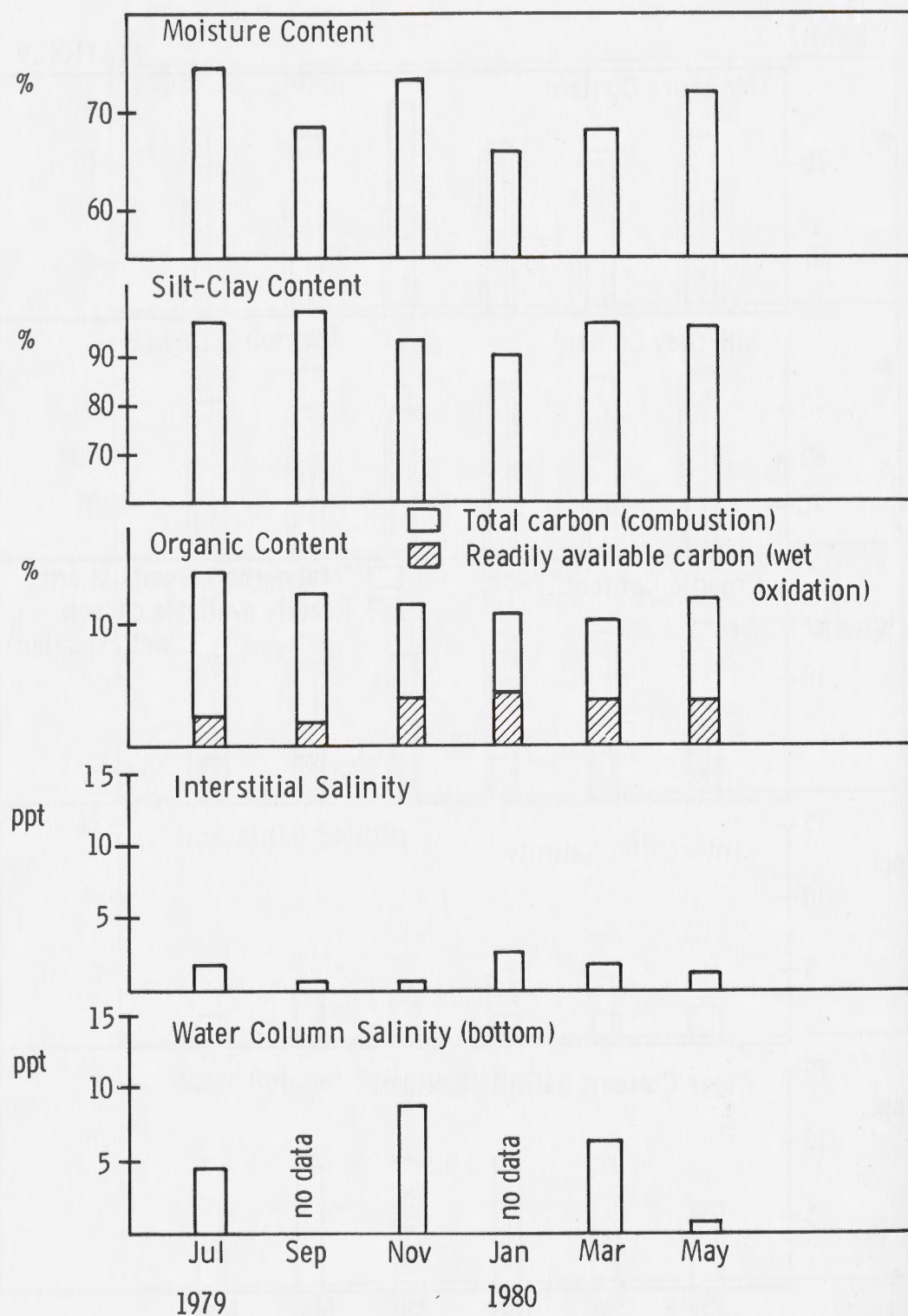


Figure 16. Physical characteristics of the sediments and water column for station 10 from July 1979 through May 1980.

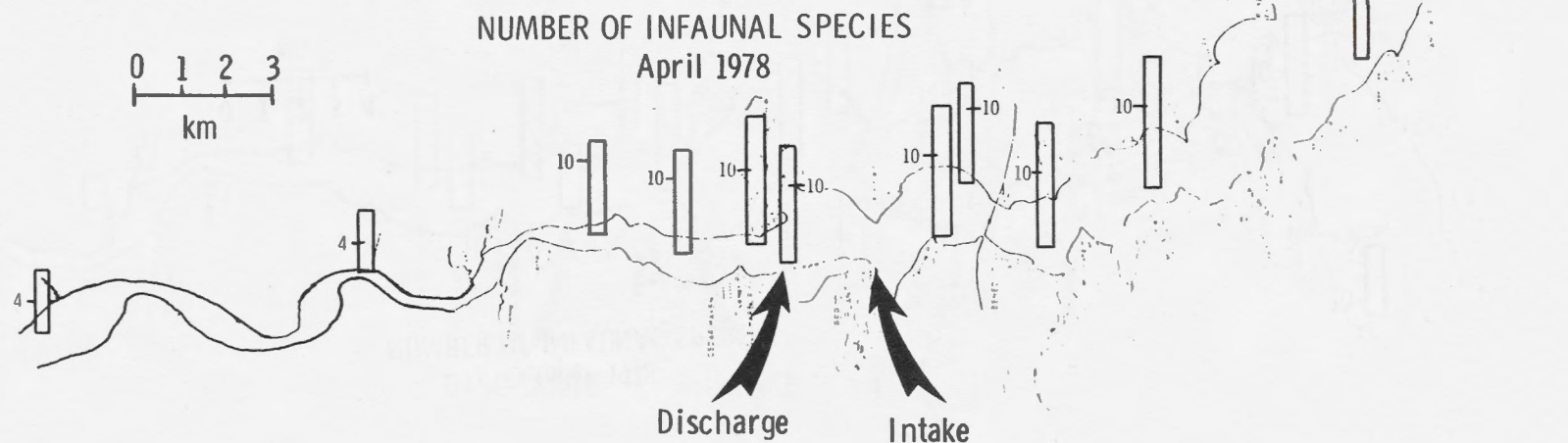
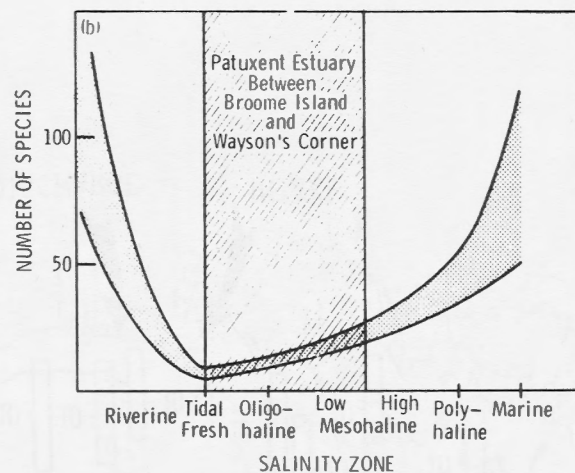
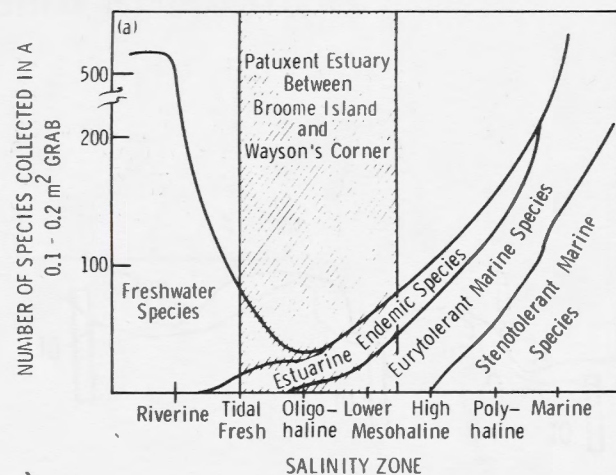


Figure 17. Number of infaunal macrobenthic species observed along the Patuxent estuary during the comprehensive survey conducted in April 1978. Insert A - Summary of changes in number and type of infaunal macrobenthic species that characteristically occur along the estuarine gradient of Chesapeake Bay tributaries and in the Atlantic Ocean area adjacent to the Bay. Insert B - Range in the number of species occurring in 0.1- to 0.2-m² grab samples along the estuarine gradient of Chesapeake Bay tributaries, and in the Atlantic Ocean area adjacent to the Bay.

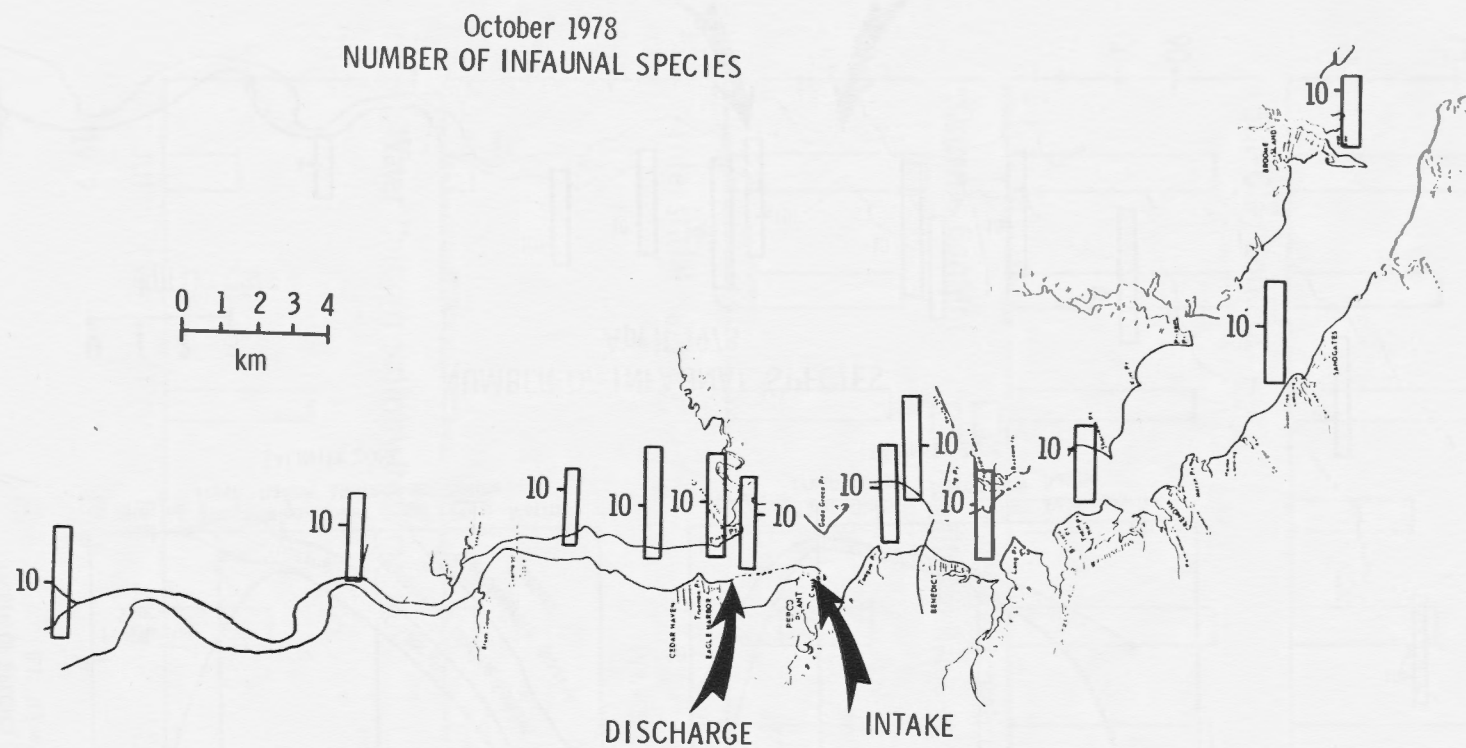



Figure 18. Number of infaunal macrobenthic species collected along the Patuxent estuary during the comprehensive survey in October 1978.

NUMBER OF INDIVIDUALS PER m²

 **Tubificodes heterochaetus**

A horizontal scale bar with tick marks at 0, 1, 2, 3, and 4. The unit 'km' is written below the bar.

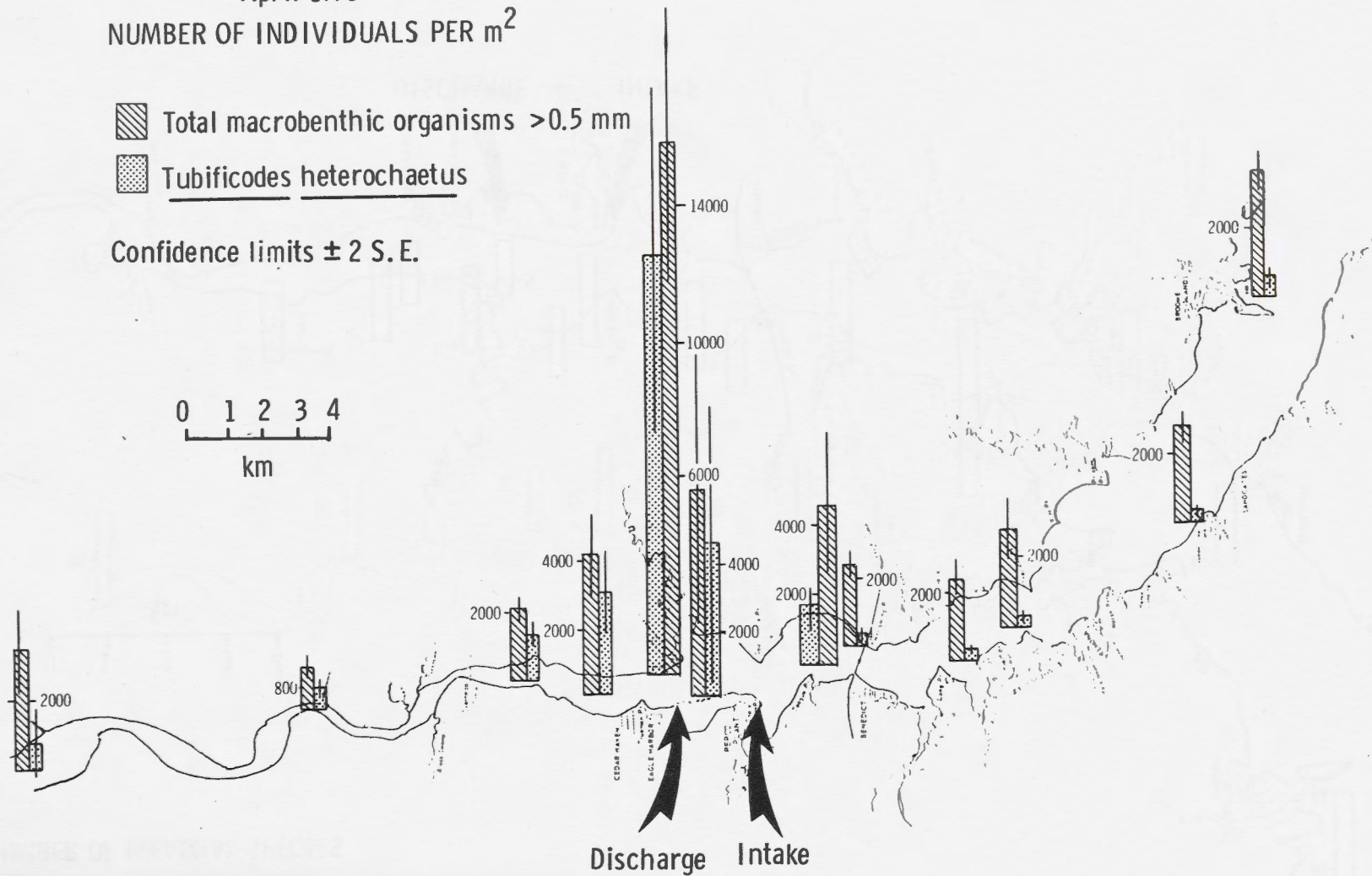


Figure 20. Mean number of infaunal macrobenthic organisms and Tubificodes heterochaetus per m² collected along the Patuxent estuary during the comprehensive survey in April 1978.

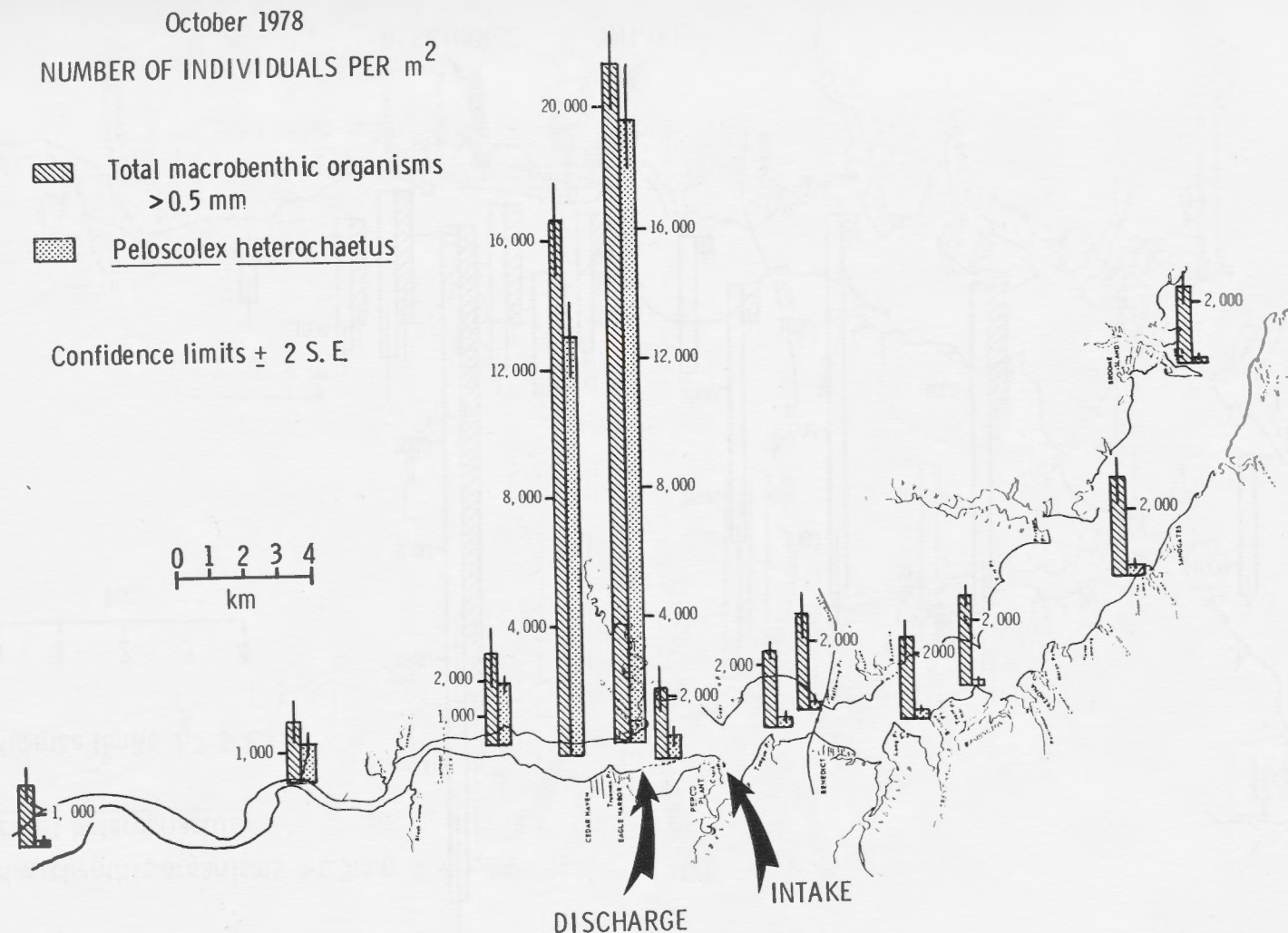


Figure 21. Mean number of infaunal macrobenthic organisms and *Peloscolex heterochaetus* per m^2 collected along the Patuxent estuary during the comprehensive survey in October 1978.

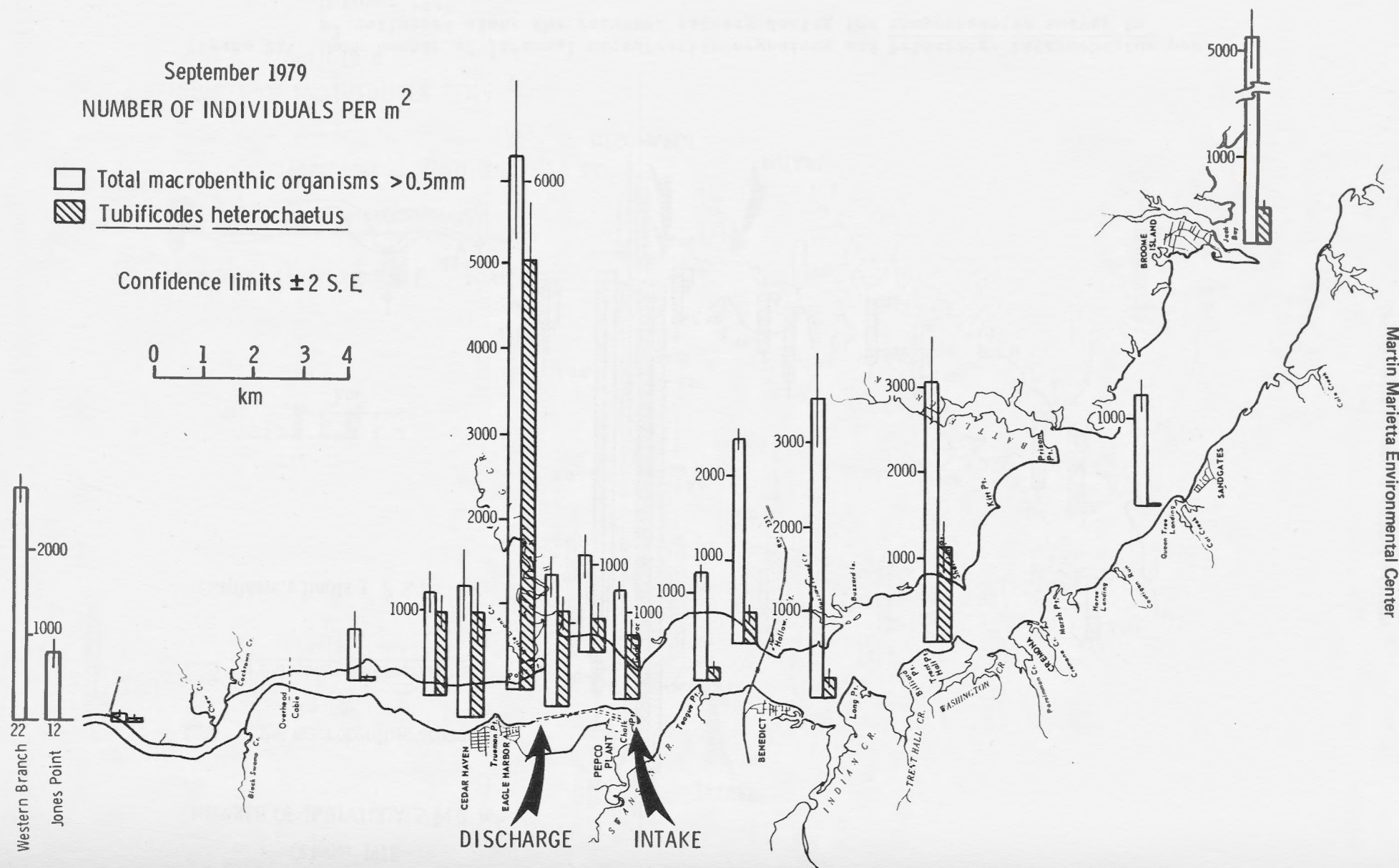


Figure 22. Mean number of infaunal macrobenthic organisms and Tubificodes heterochaetus per m² collected along the Patuxent estuary during the comprehensive survey in September 1979.

April 1978
ASH-FREE DRY WEIGHT

- Total benthic organisms >0.5 mm (g/m²)
■ Excluding biomass of Macoma balthica (g/m²)

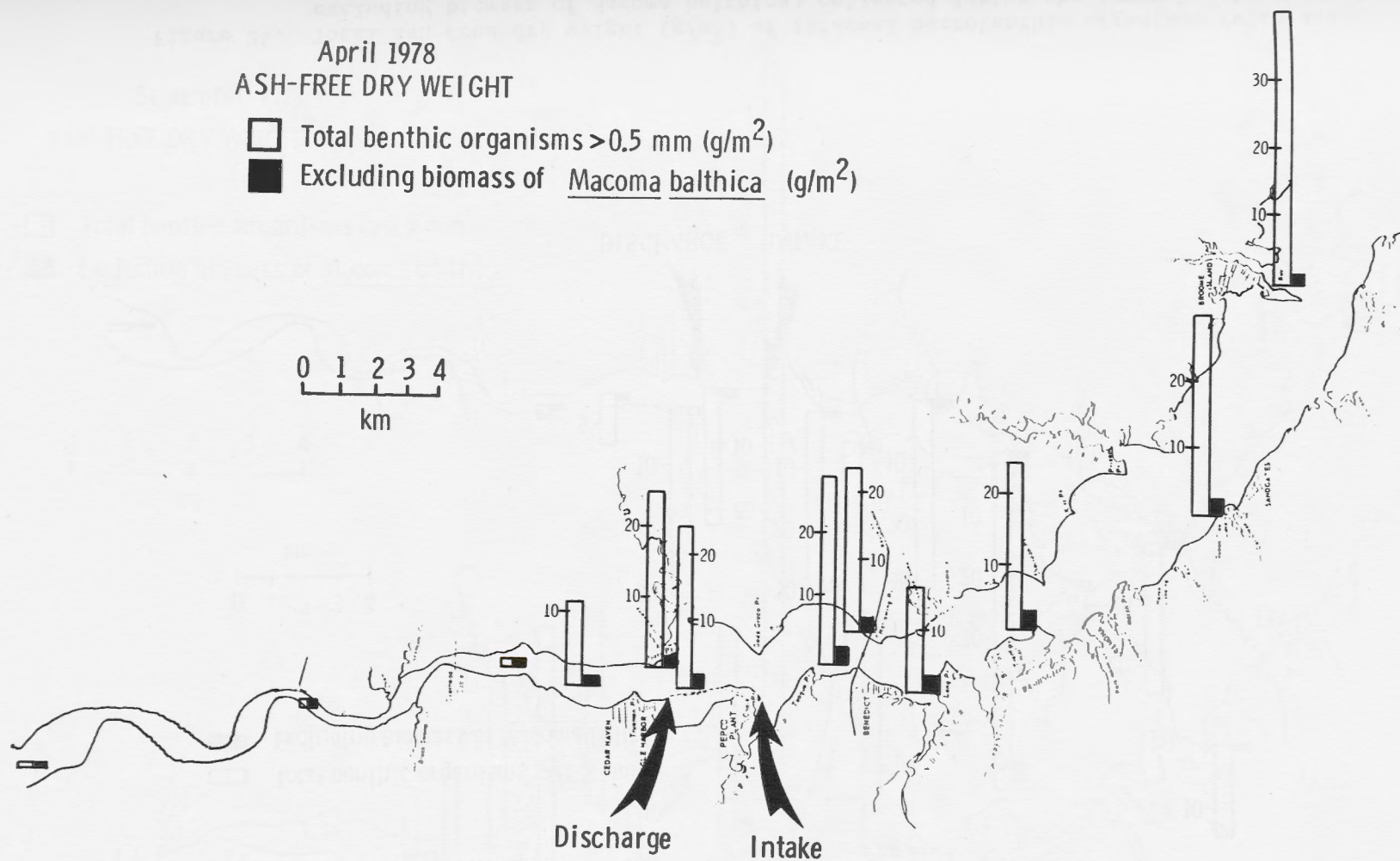


Figure 23. Total ash-free dry weight (g/m²) of infaunal macrobenthic organisms (with and excluding biomass of Macoma balthica) collected during the comprehensive survey in April 1978.

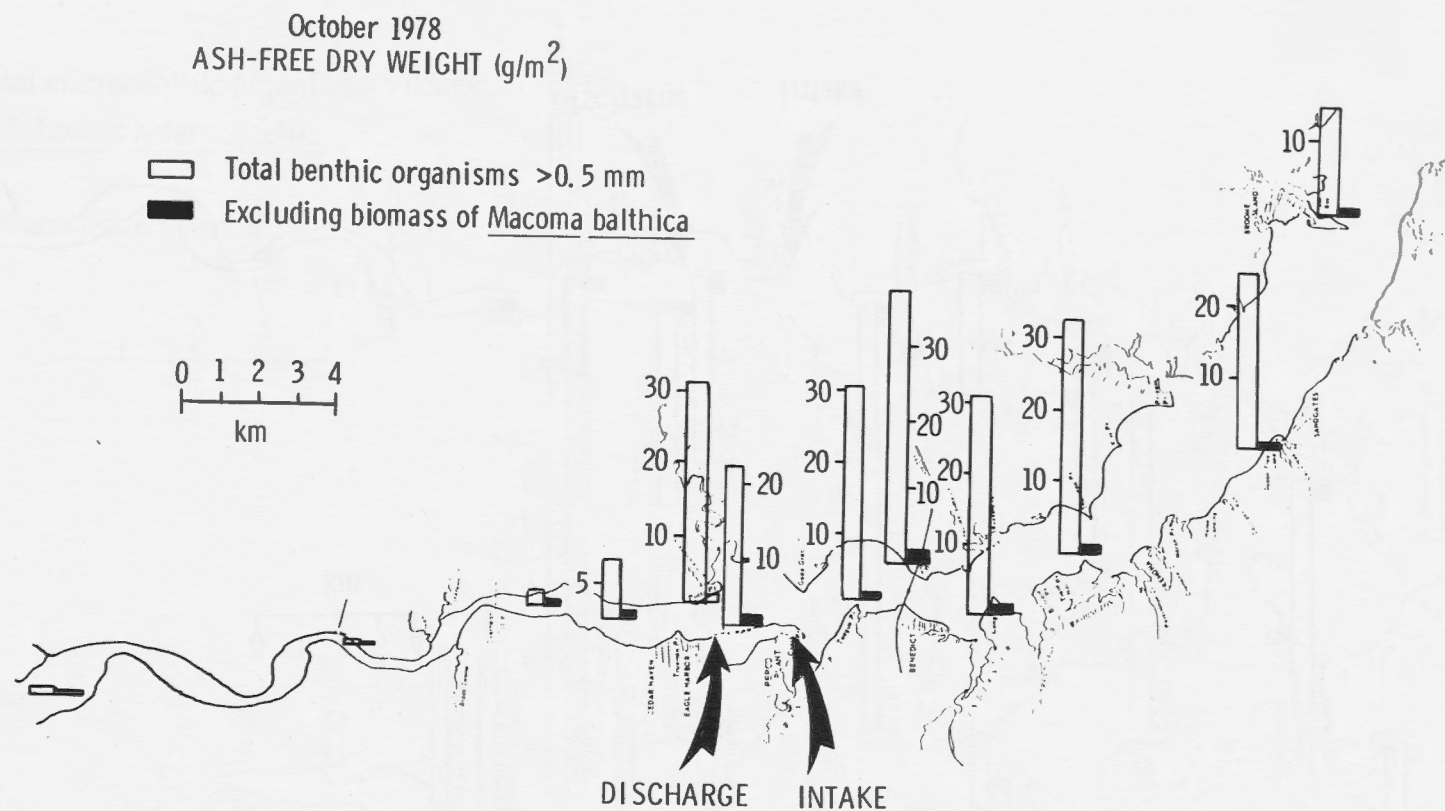


Figure 24. Total ash-free dry weight (g/m^2) of infaunal macrobenthic organisms (with and excluding biomass of *Macoma balthica*) collected during the comprehensive survey in October 1978.

September 1979
ASH-FREE DRY WEIGHT (g/m^2)

- Total benthic organisms $>0.5 \text{ mm}$
■ Excluding biomass of Macoma balthica

0 1 2 3 4
km

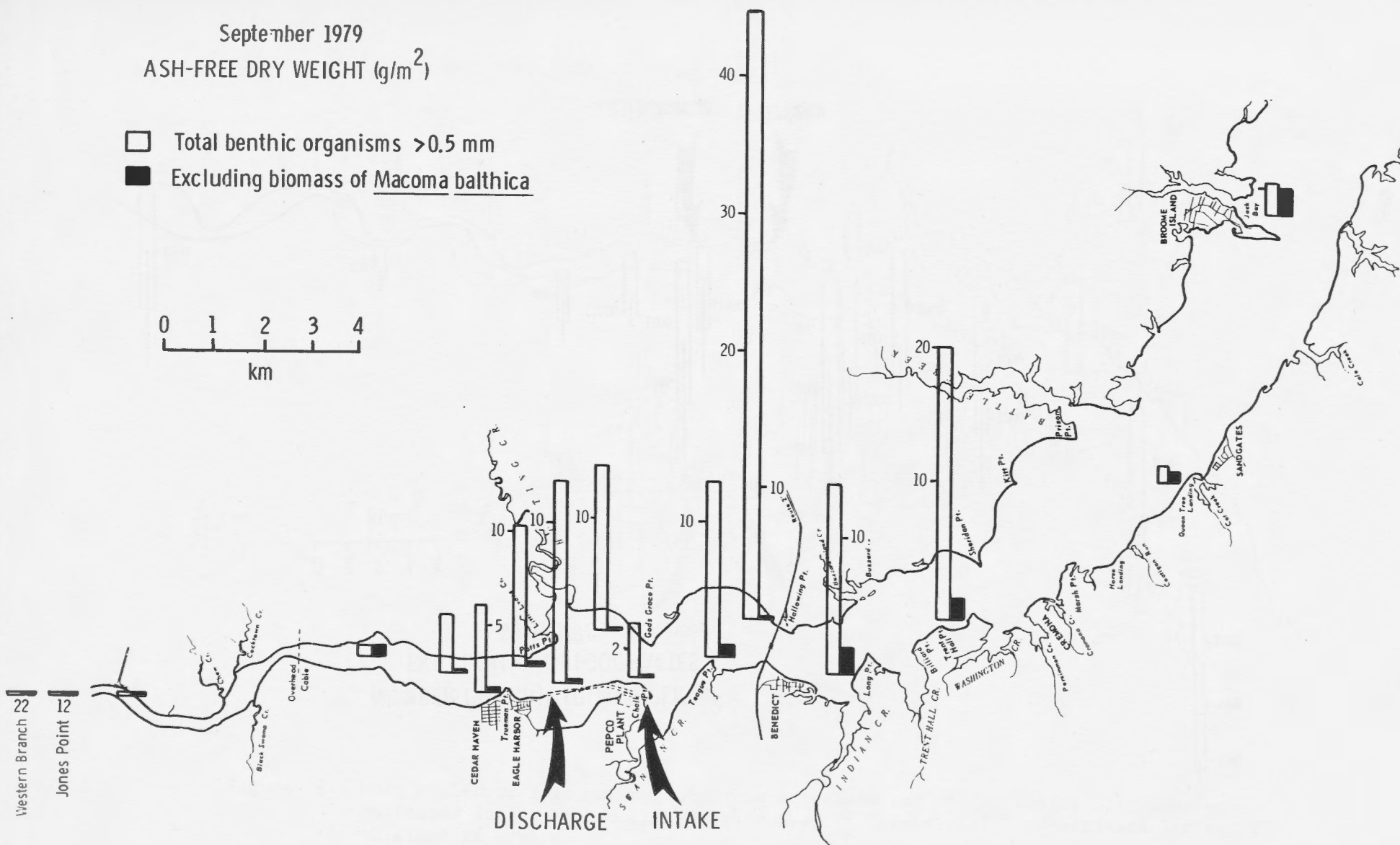


Figure 25. Total ash-free dry weight (g/m^2) of infaunal macrobenthic organisms (with and excluding biomass of Macoma balthica) collected along the Patuxent estuary during the comprehensive survey in September 1979.

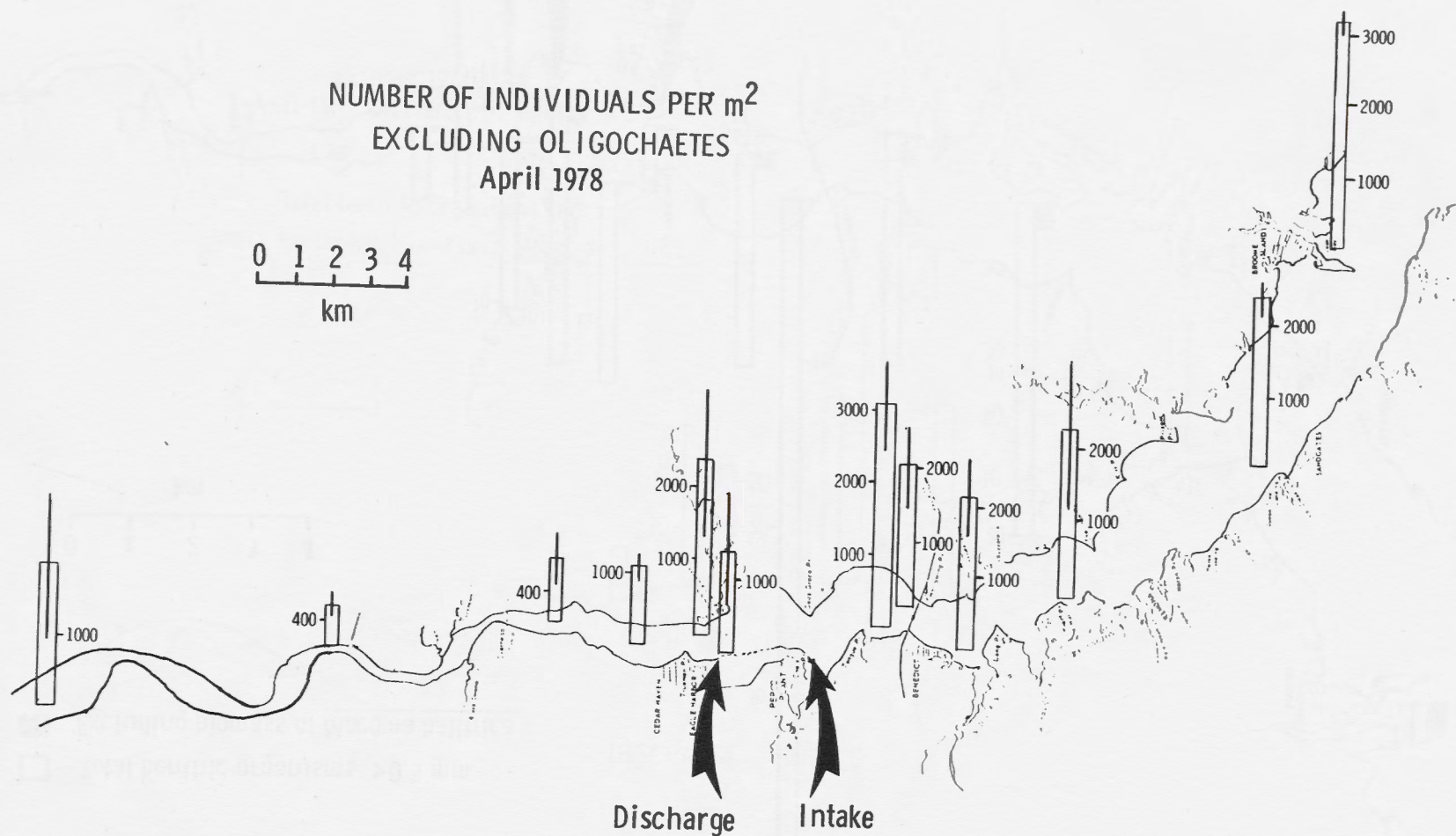
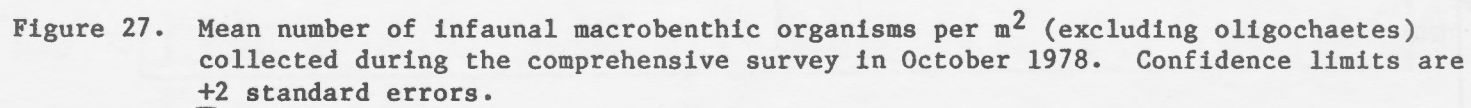


Figure 26. Mean number of infaunal organisms per m^2 (excluding oligochaetes) collected during the comprehensive survey in April 1978. Confidence limits are ± 2 standard errors.

A horizontal number line with tick marks at 0, 1, 2, 3, and 4. The unit is labeled 'km' below the line.



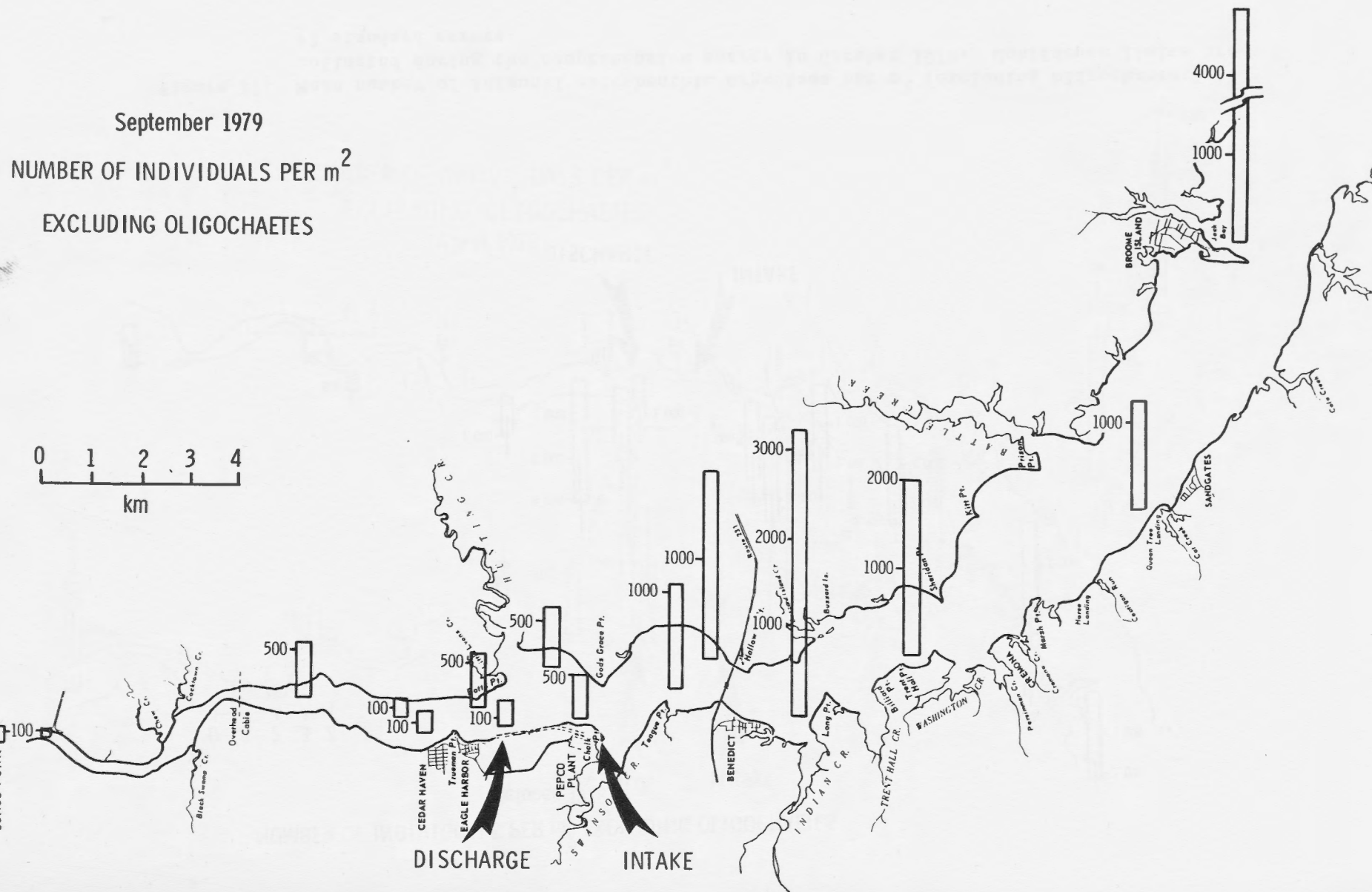


Figure 28. Mean number of infaunal macrobenthic organisms per m^2 (excluding oligochaetes) collected along the Patuxent estuary during the comprehensive survey in September 1979.

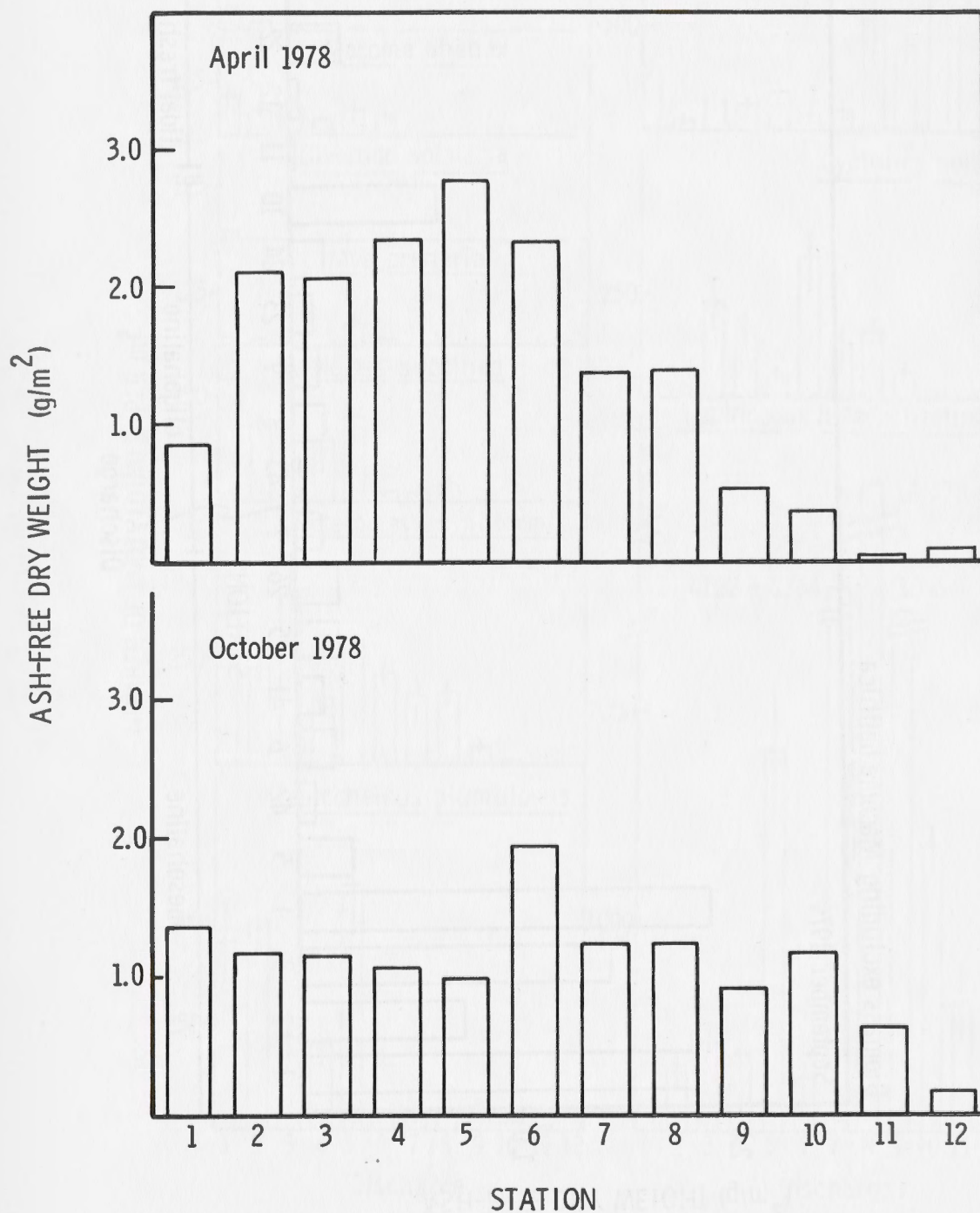


Figure 29. Ash-free dry weight (g/m²) of infaunal macrobenthic organisms (excluding biomass of Macoma balthica) during the comprehensive surveys in 1978.

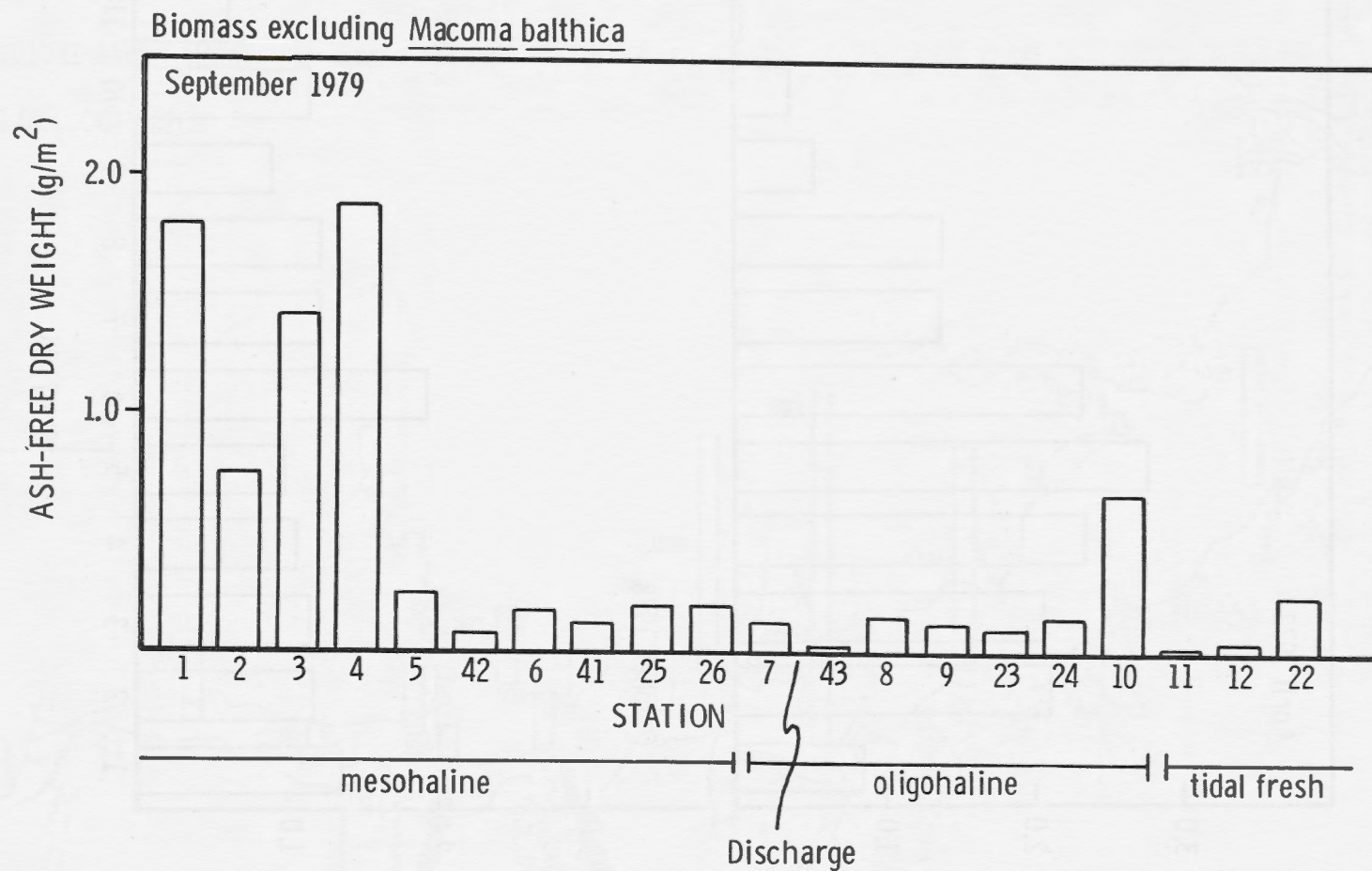


Figure 30. Ash-free dry weight (g/m²) of infaunal macrobenthic organisms (excluding biomass of Macoma balthica) during the comprehensive survey in September 1979.

APRIL 1978

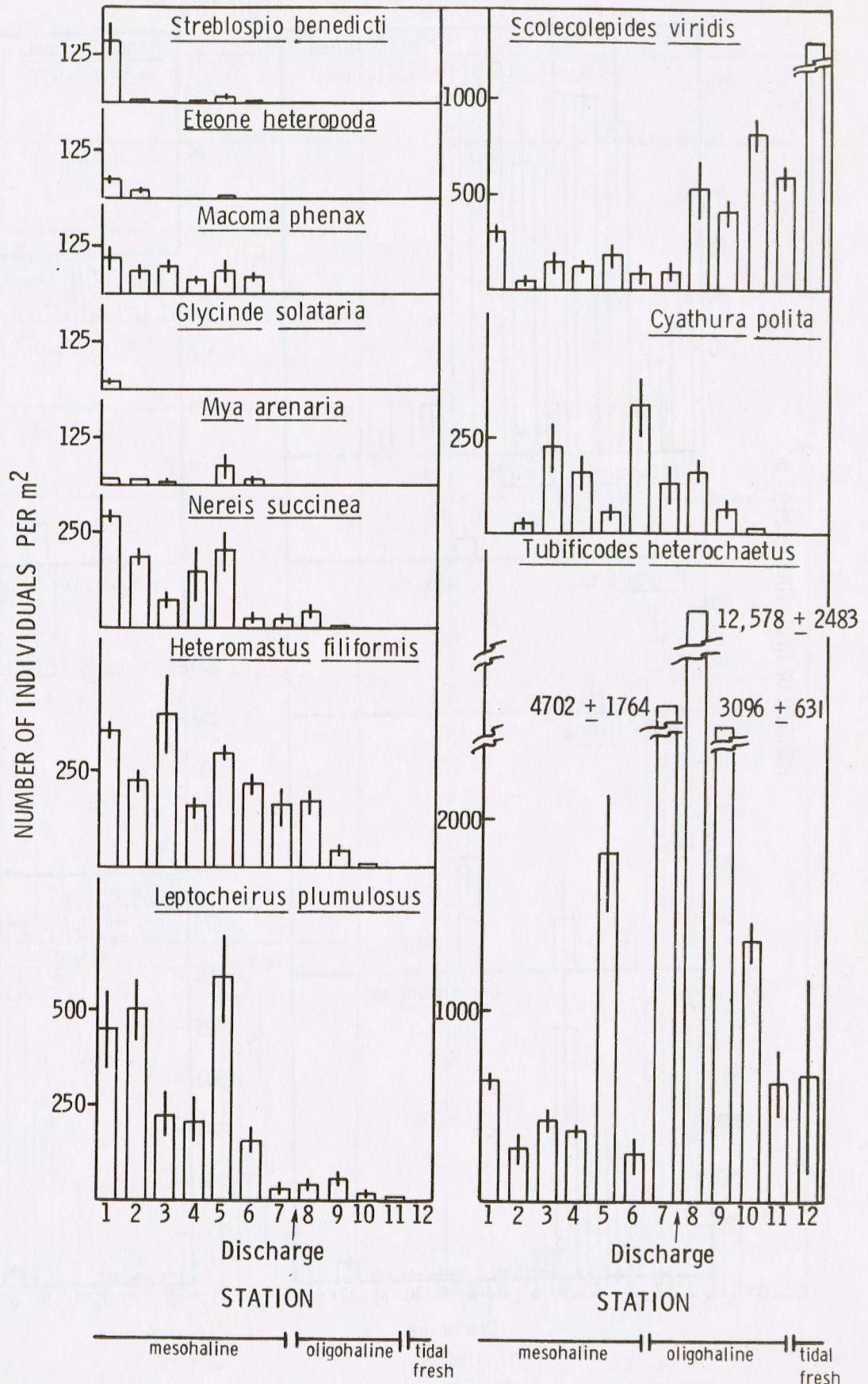


Figure 31. Mean densities of some of the abundant infaunal species during the comprehensive survey conducted in April 1978. Confidence limits shown are ± 1 standard error.

APRIL 1978

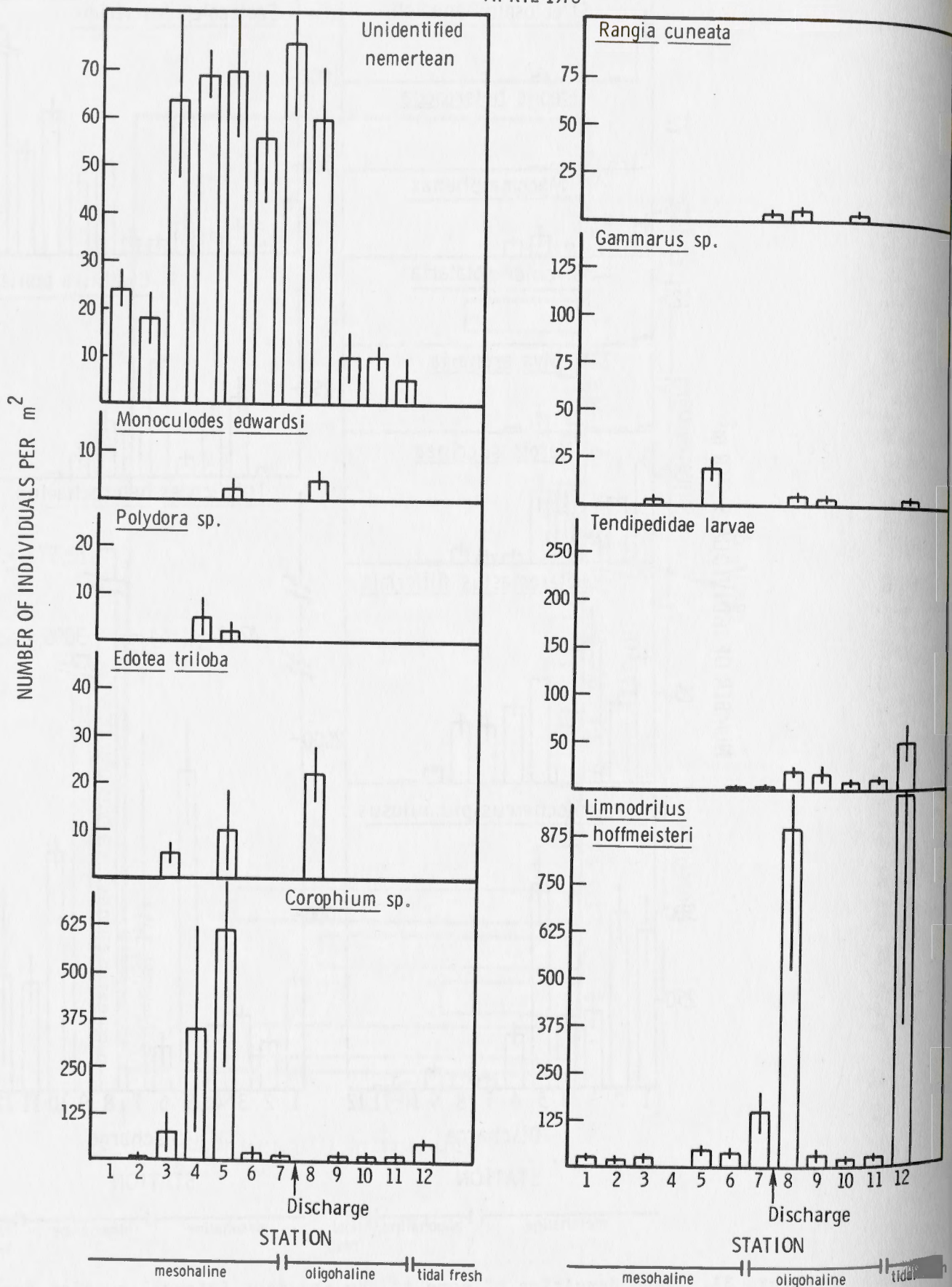


Figure 32. Mean densities of some of the less abundant infaunal species during the comprehensive survey in April 1978. Confidence limits shown are ± 1 standard error.

OCTOBER 1978

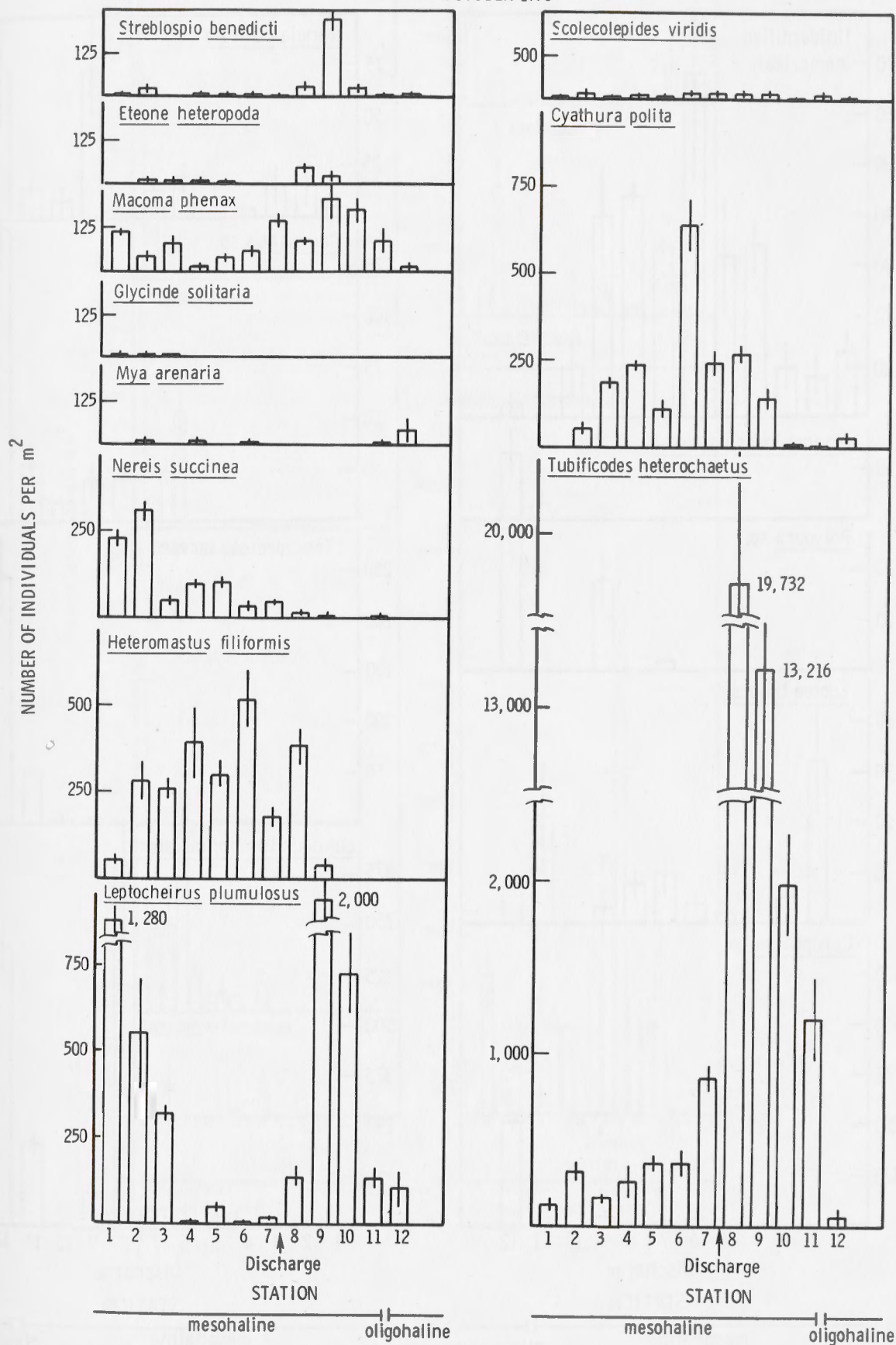


Figure 33. Mean densities of some of the abundant infaunal species during the comprehensive survey in October 1978. Confidence limits shown are ± 1 standard error.

OCTOBER 1978

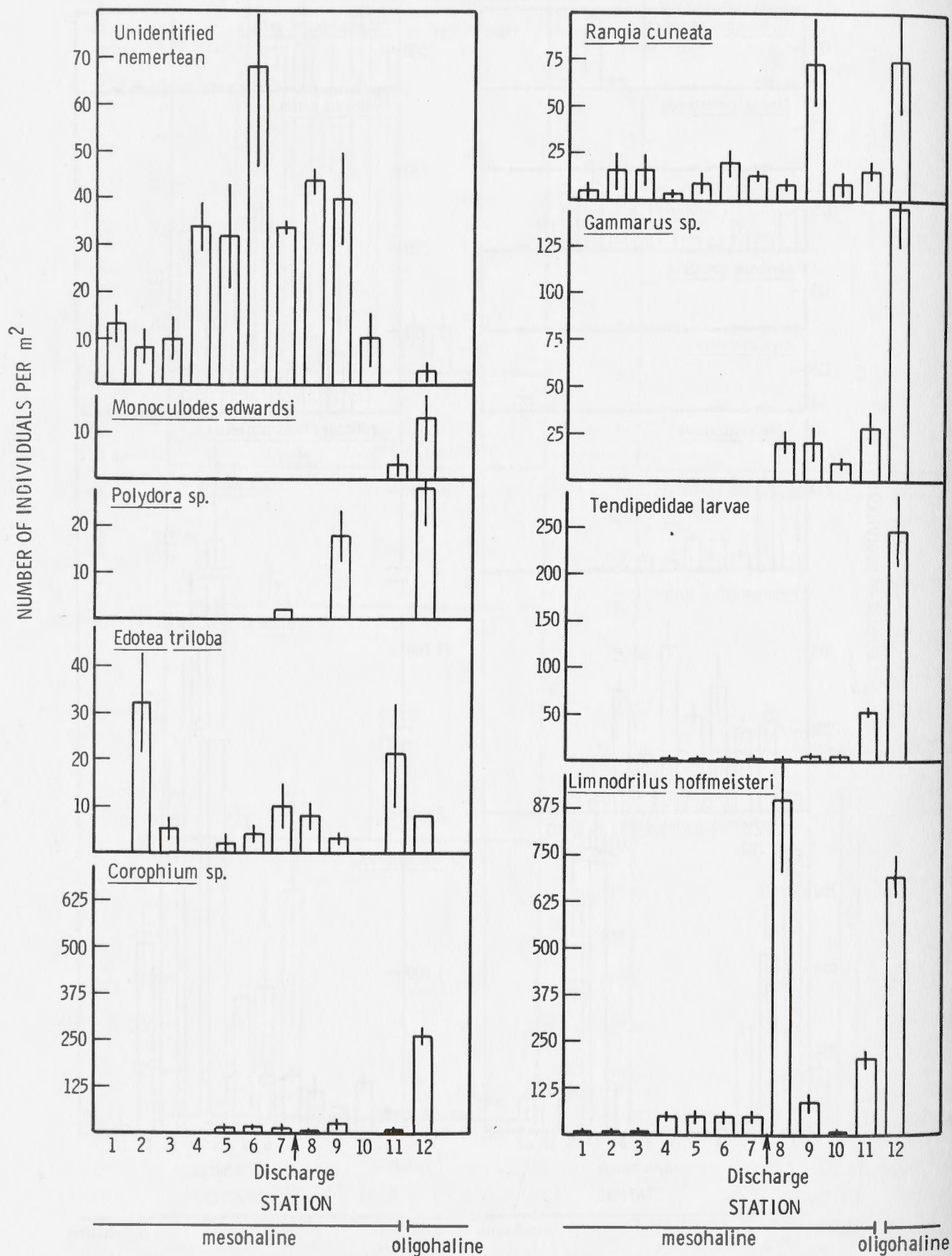


Figure 34. Mean densities of some of the less abundant infaunal species during the comprehensive survey in October 1978. Confidence limits shown are ± 1 standard error.

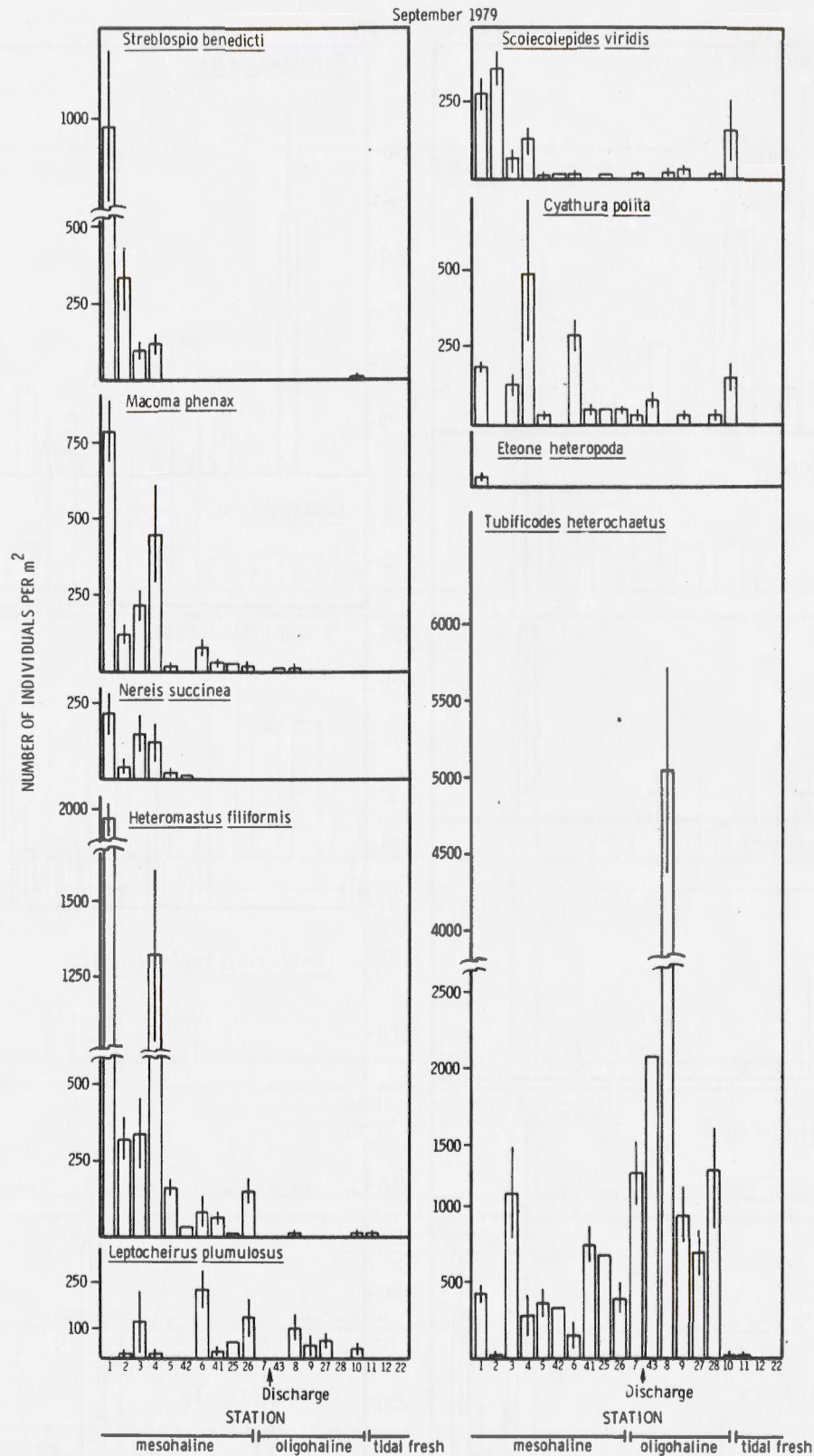


Figure 35. Mean densities of some of the abundant infaunal species during the comprehensive survey in September 1979. Confidence limits shown are ± 1 standard error.

September 1979

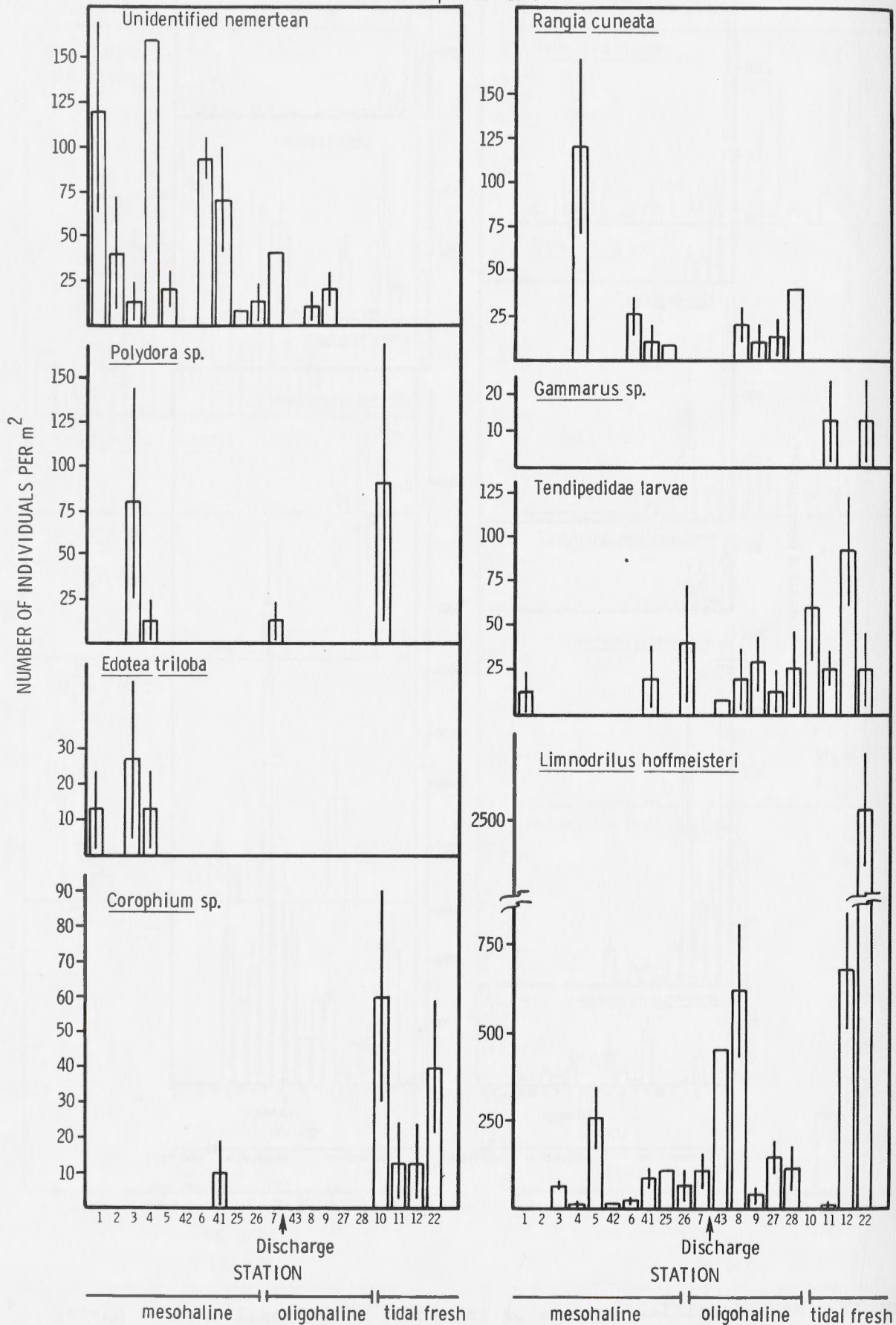


Figure 36. Mean densities of some of the less abundant infaunal species during the comprehensive survey in September 1979. Confidence limits shown are ± 1 standard error.

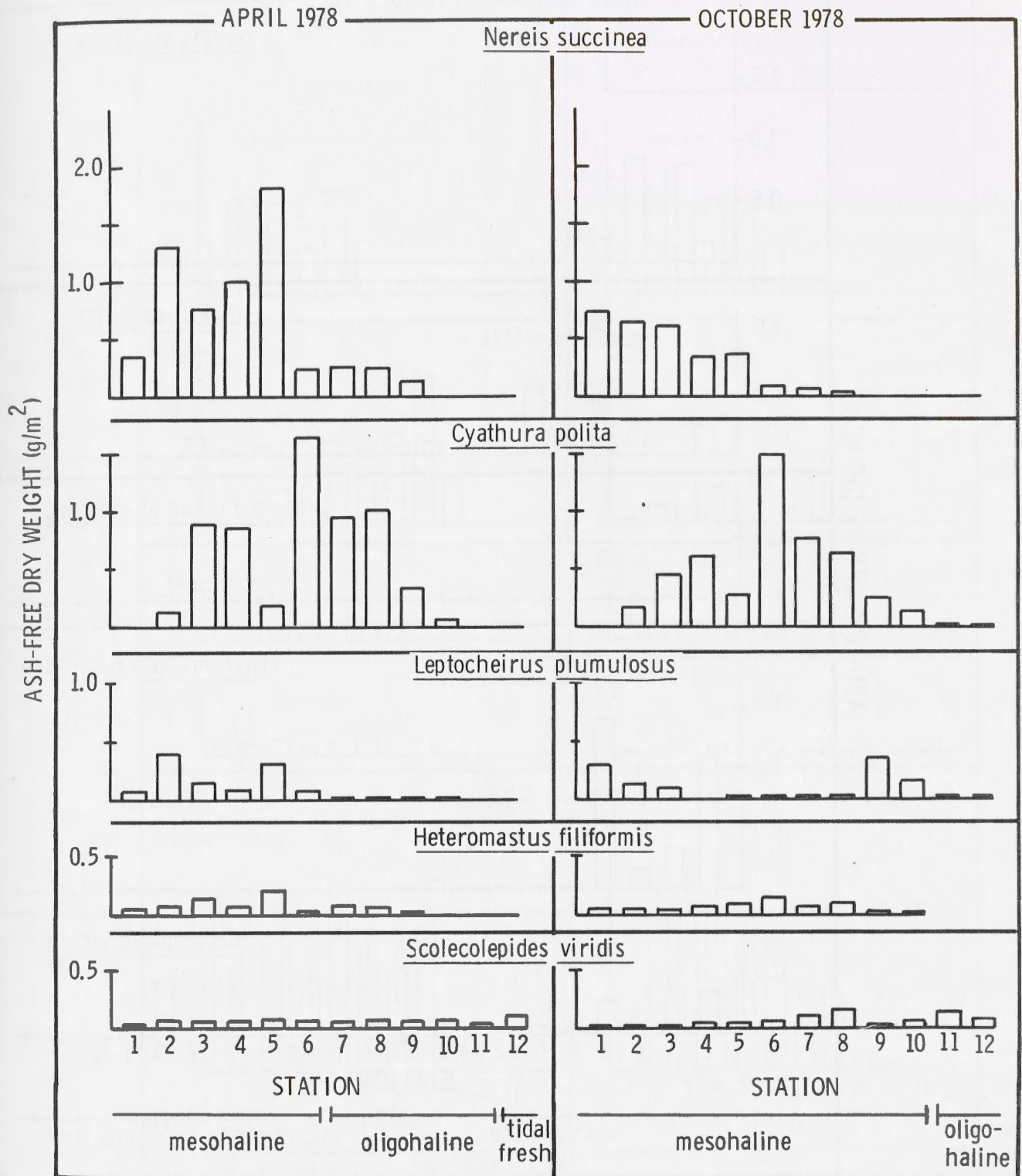


Figure 37. Ash-free dry weights (g/m²) of abundant infaunal macrobenthic species during the comprehensive surveys in 1978.

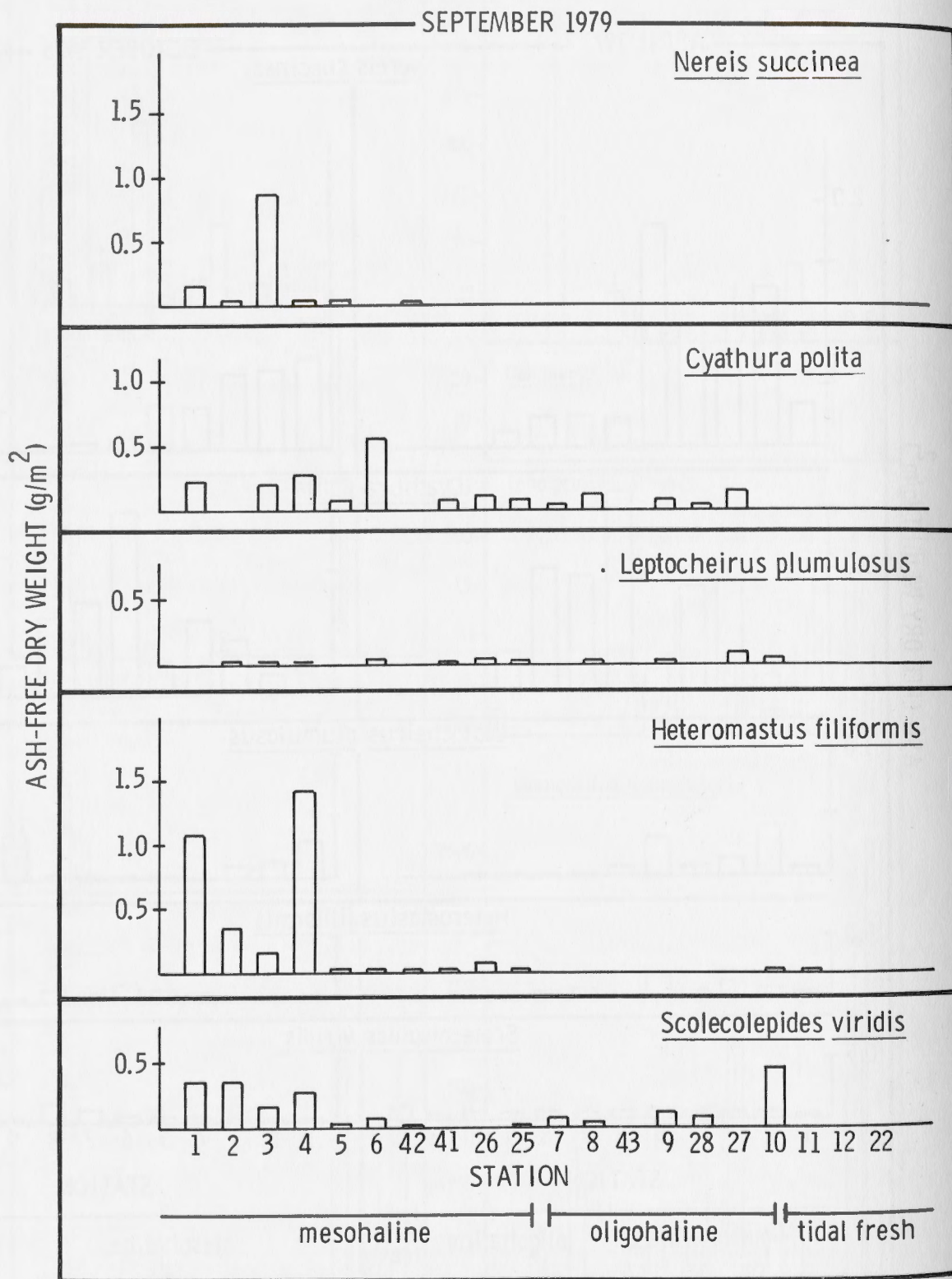


Figure 38. Ash-free dry weights (g/m²) of abundant infaunal macrobenthic species during the comprehensive survey in September 1979.

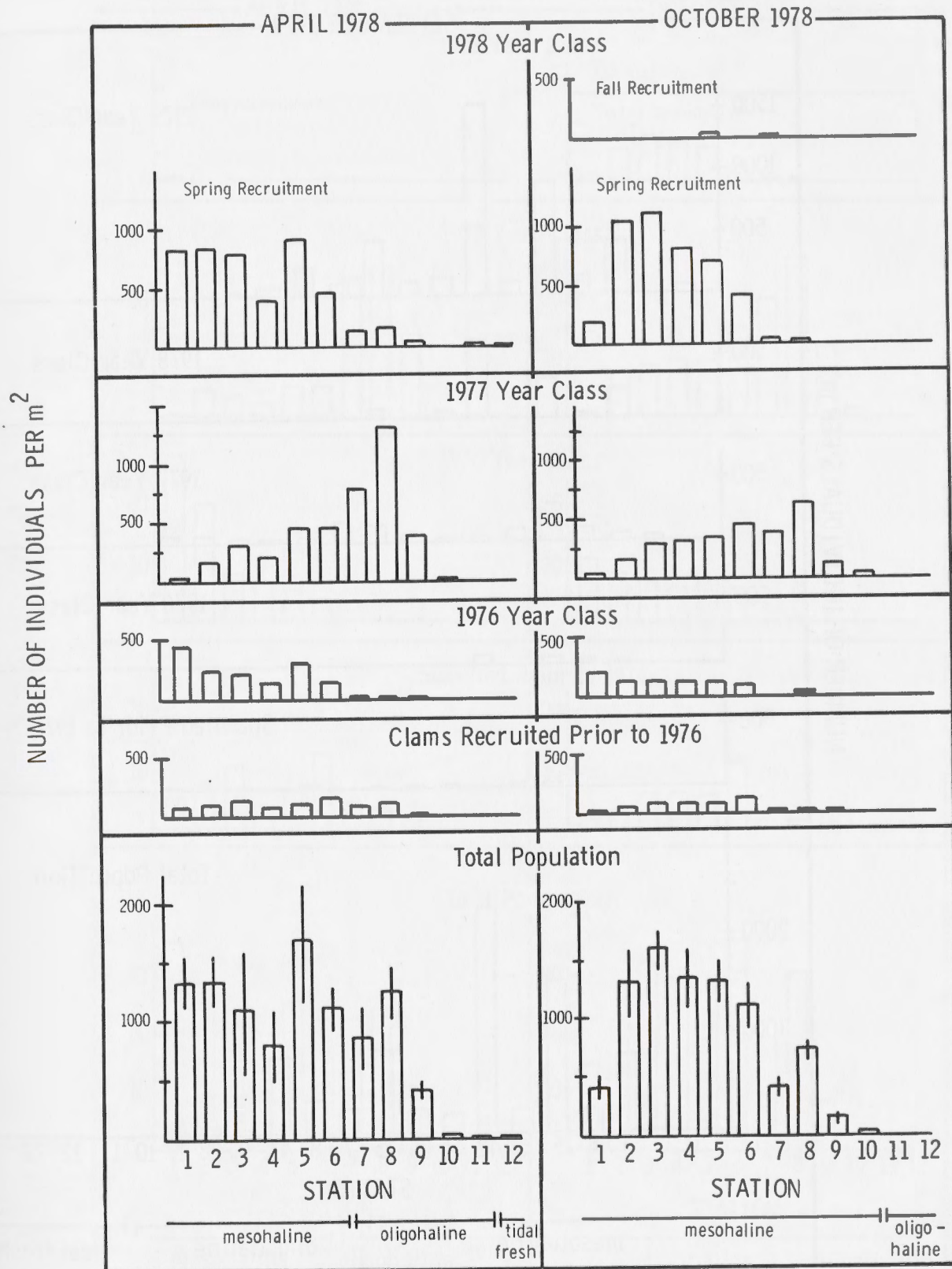


Figure 39. Mean densities of *Macoma balthica* during the comprehensive survey in 1978. Confidence limits shown are ± 1 standard error.

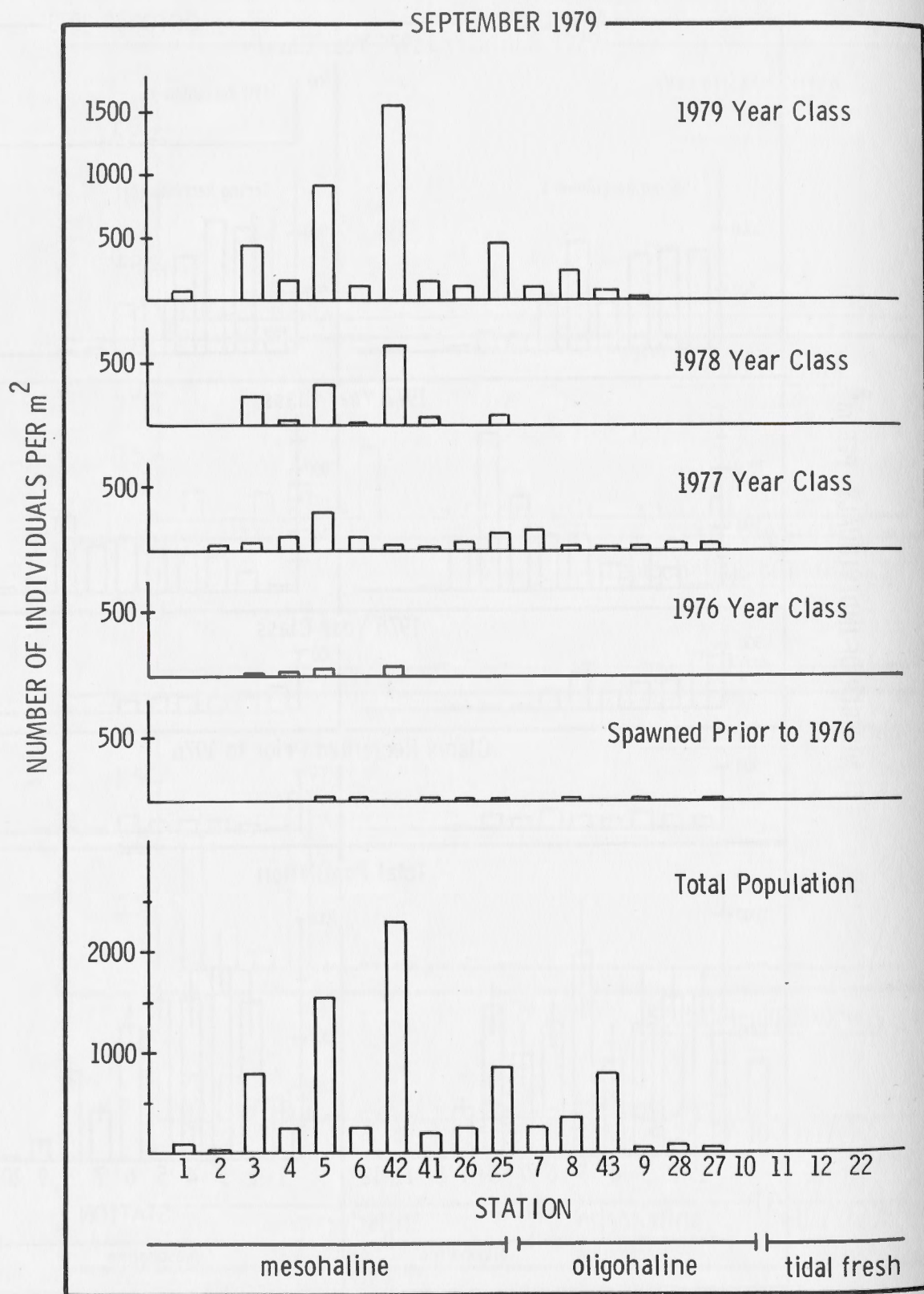


Figure 40. Mean densities of Macoma balthica per m^2 during the comprehensive survey in September 1979.

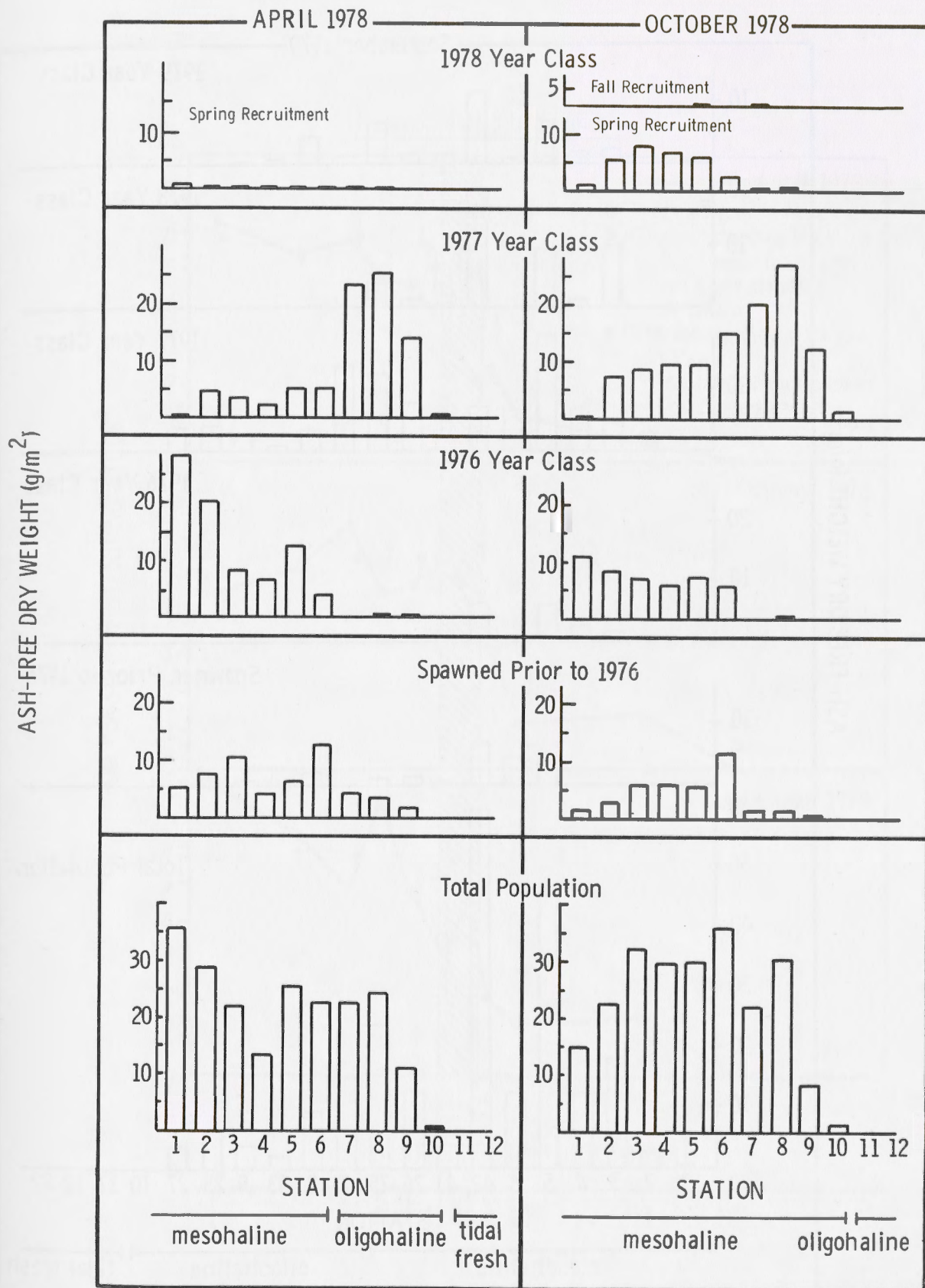


Figure 41. Ash-free dry weights (g/m²) of Macoma balthica during the comprehensive surveys in 1978.

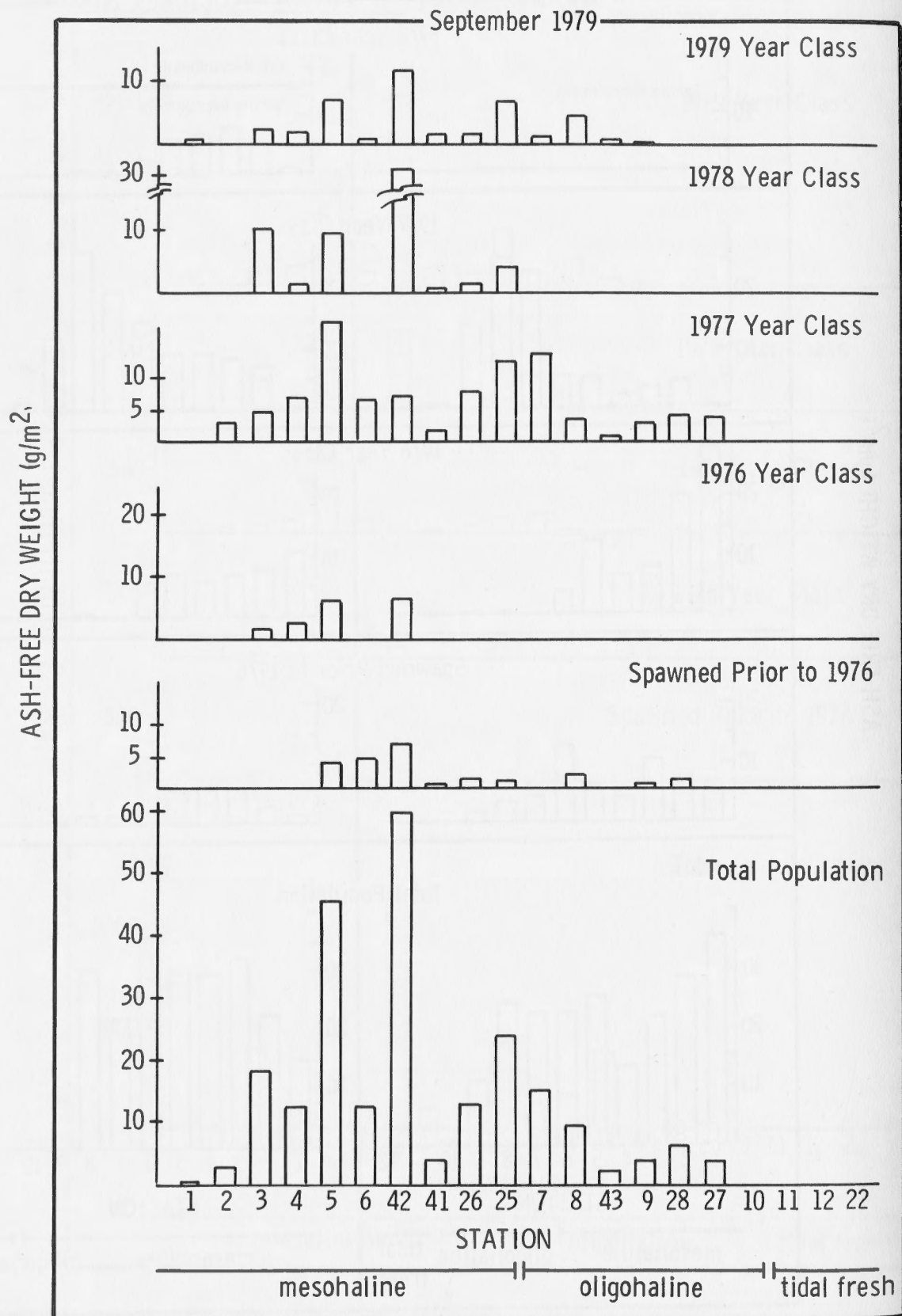


Figure 42. Ash-free dry weight (g/m²) of Macoma balthica during the comprehensive survey in September 1979.

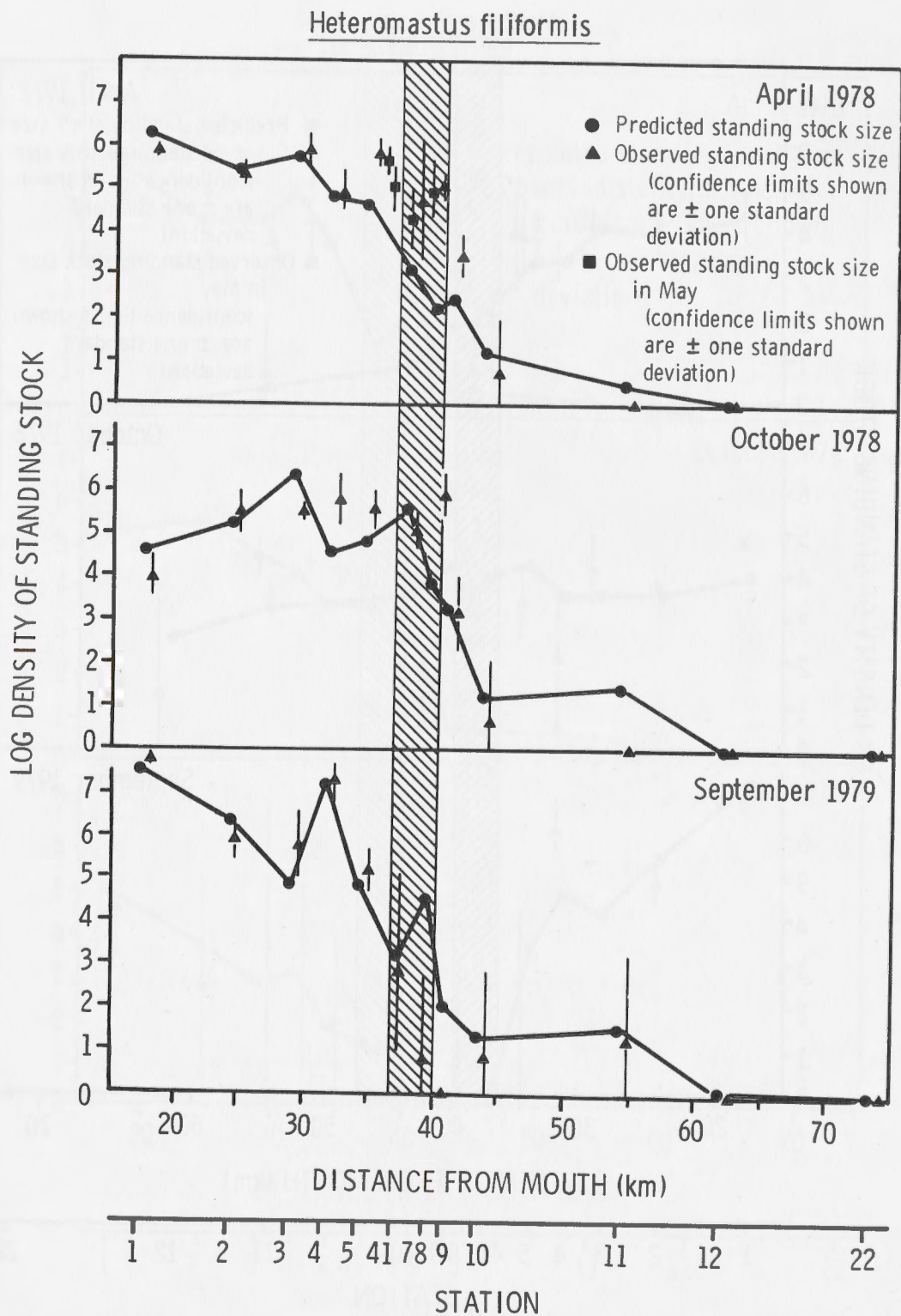


Figure 43. Graphic comparison of the density of the Heteromastus filiformis standing stock during comprehensive surveys. Hatched areas indicate regions receiving maximum exposure to excess temperatures and whose data were not used in model derivation.

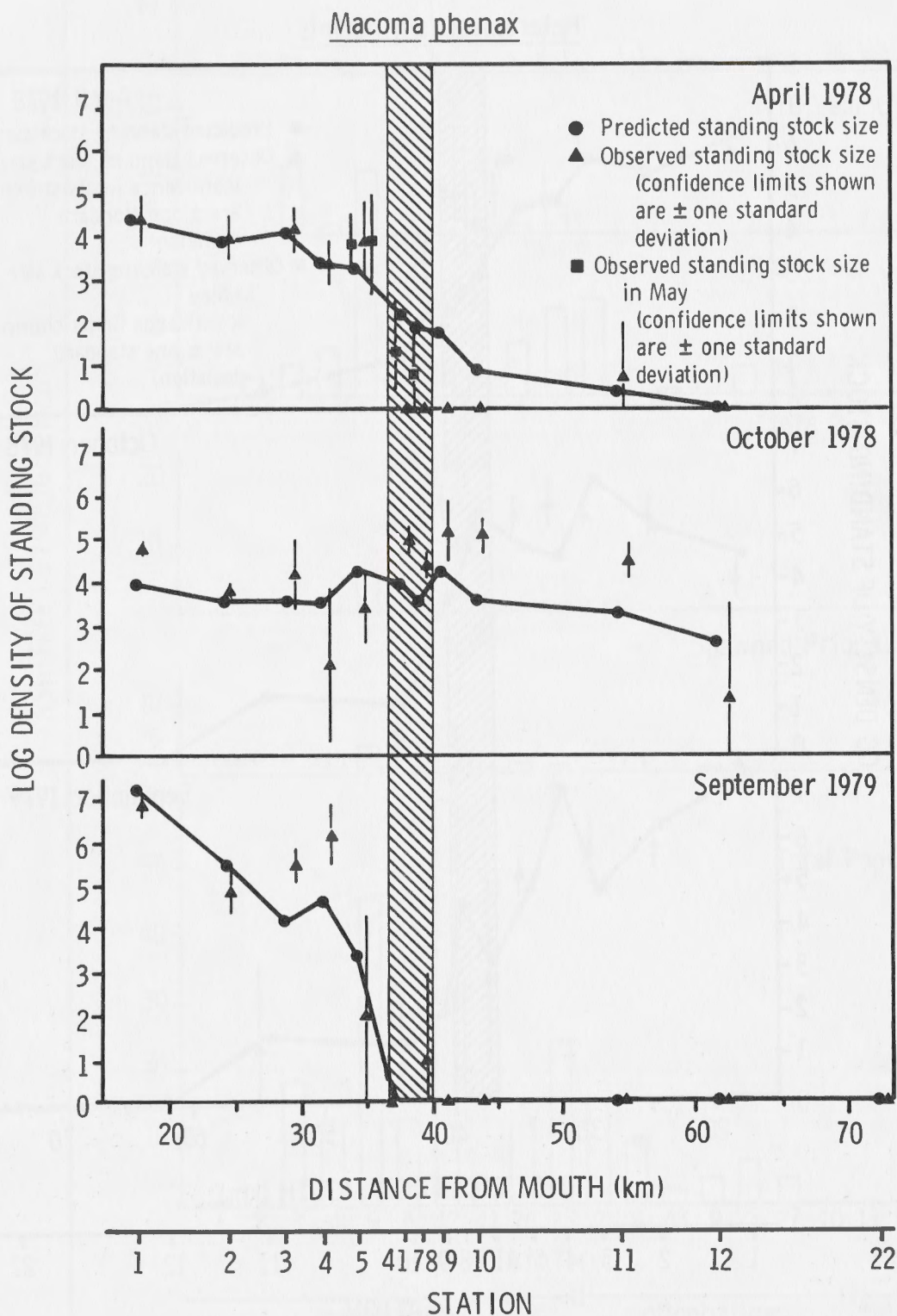


Figure 44. Graphic comparison of the density of the Macoma phenax standing stock during comprehensive surveys. Hatched areas indicate regions receiving maximum exposure to excess temperatures and whose data were not used in model derivation.

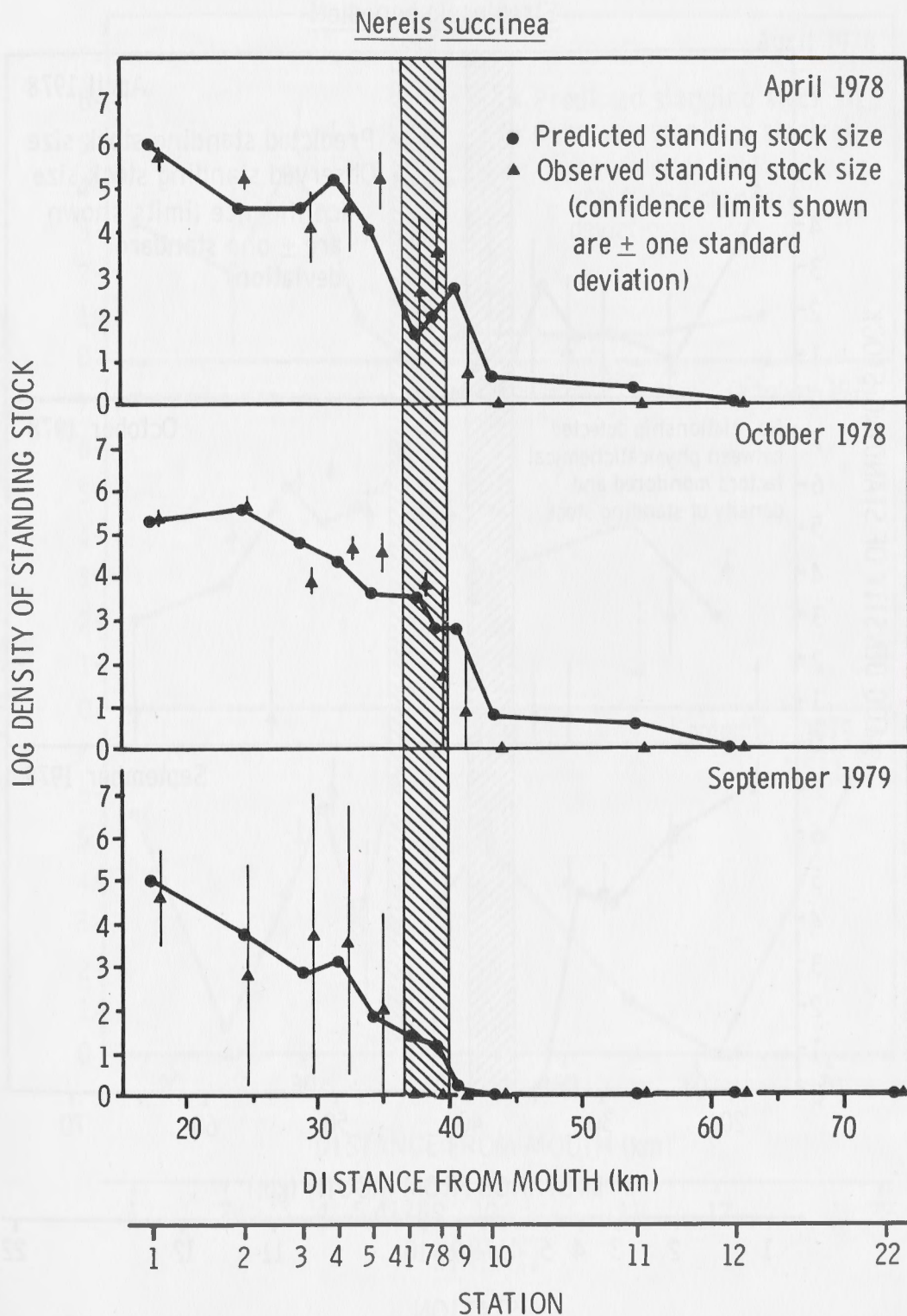


Figure 45. Graphic comparison of the density of the Nereis succinea standing stock during comprehensive surveys. Hatched areas indicate regions receiving maximum exposure to excess temperatures and whose data were not used in model derivation.

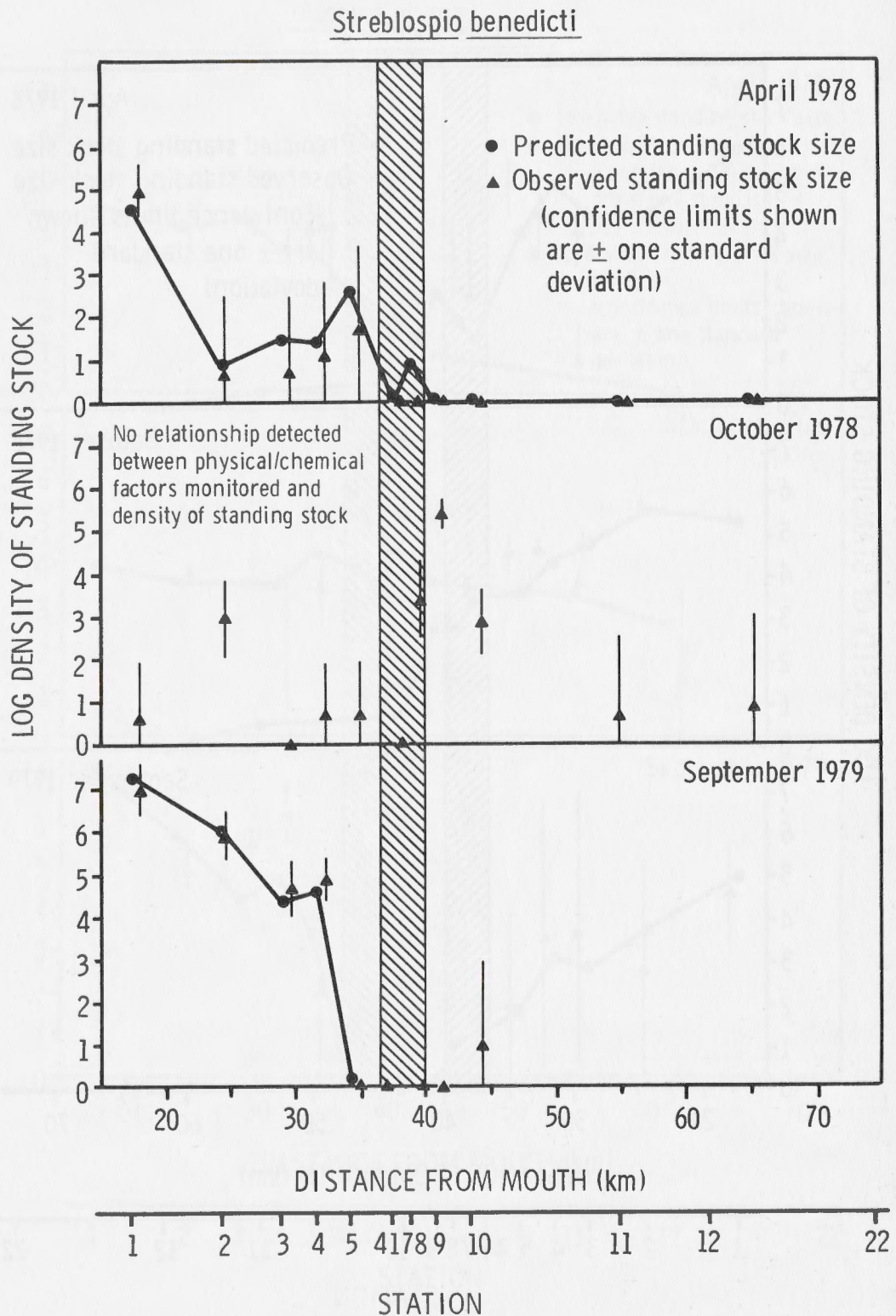


Figure 46. Graphic comparison of the density of the Streblospio benedicti standing stock during comprehensive surveys. Hatched areas indicate regions receiving maximum exposure to excess temperatures and whose data were not used in model derivation.

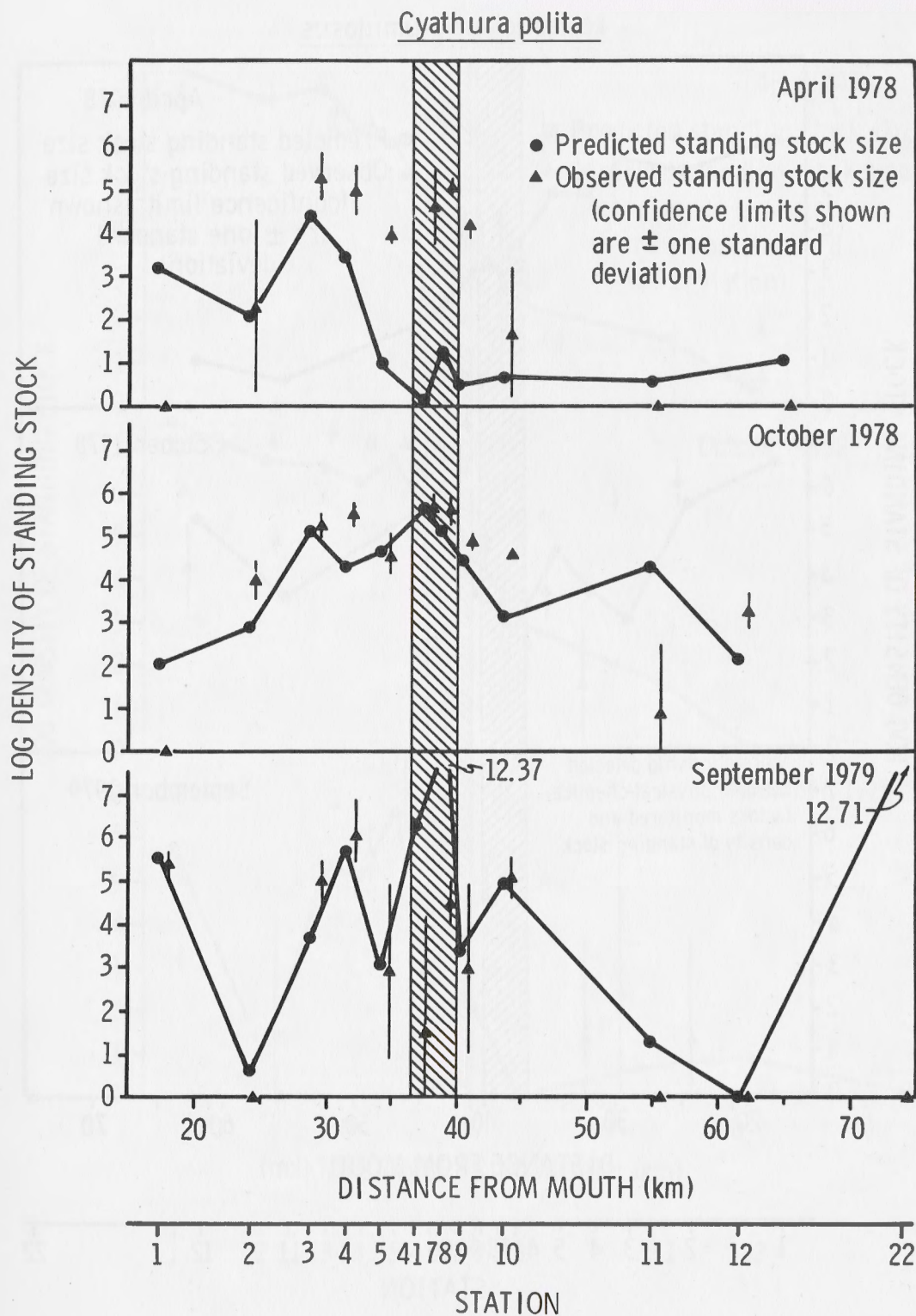


Figure 47. Graphic comparison of the density of the Cyathura polita standing stock during comprehensive surveys. Hatched areas indicate regions receiving maximum exposure to excess temperatures and whose data were not used in model derivation.

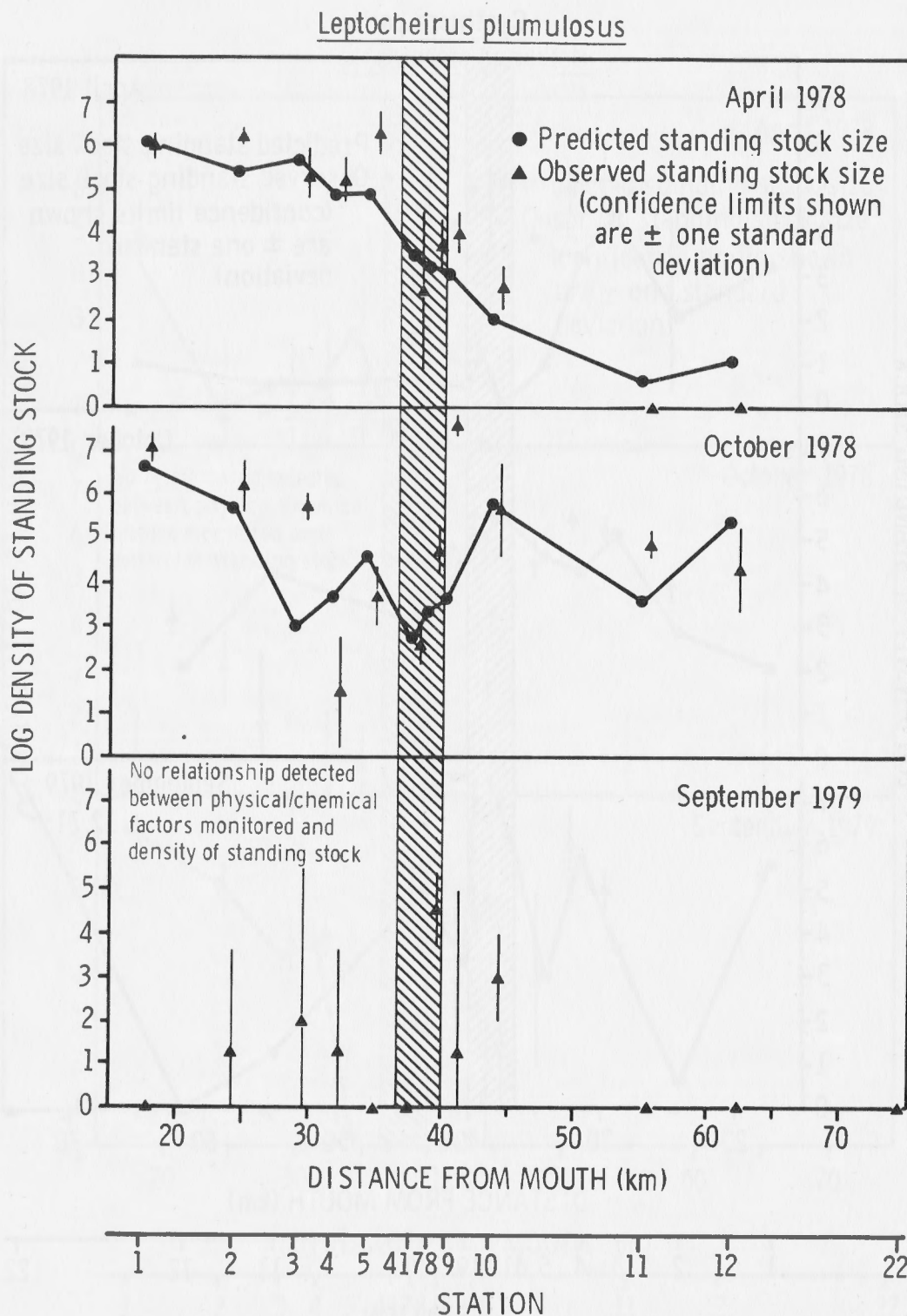


Figure 48. Graphic comparison of the density of the Leptocheirus plumulosus standing stock during comprehensive surveys. Hatched areas indicate regions receiving maximum exposure to excess temperatures and whose data were not used in model derivation.

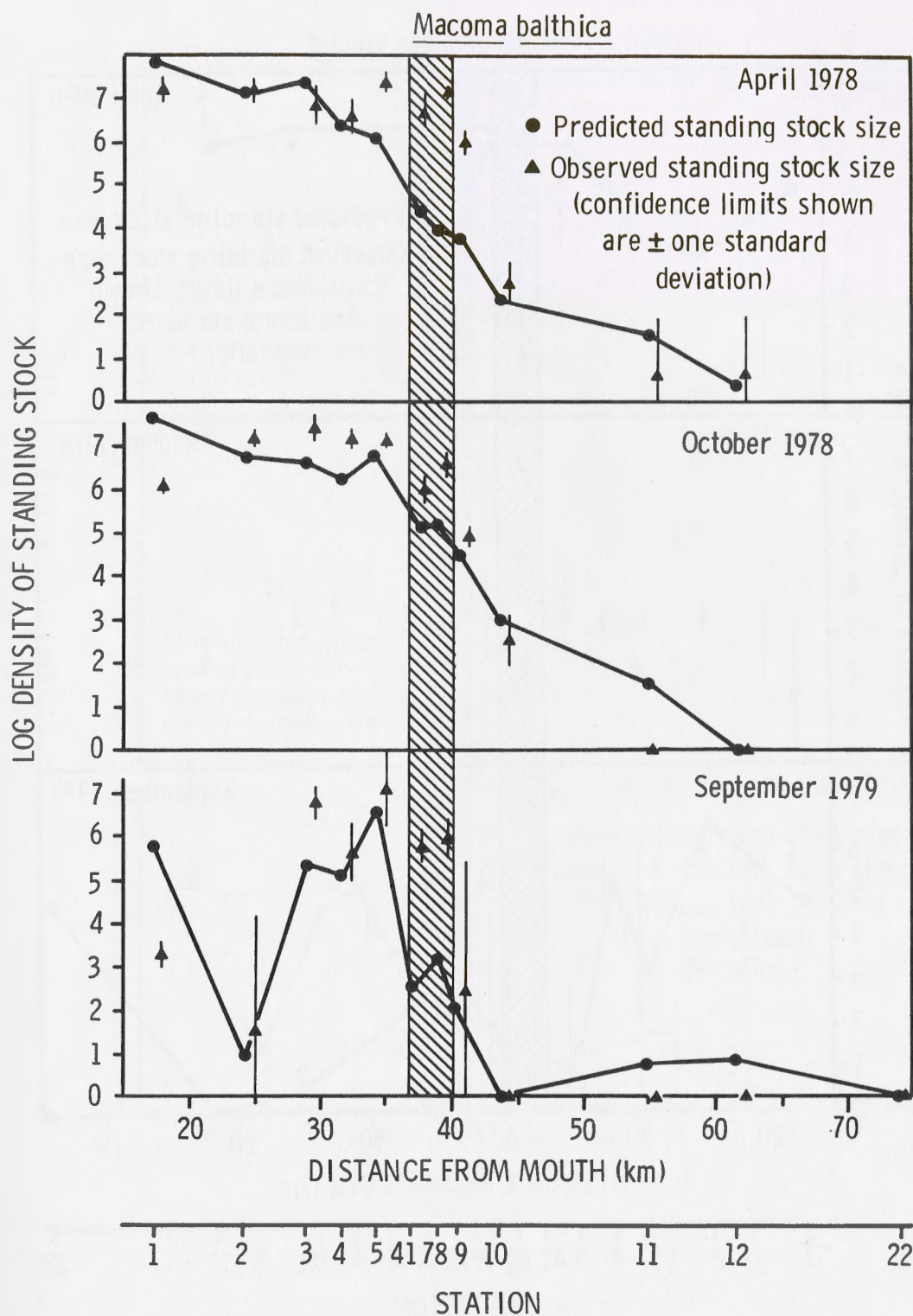


Figure 49. Graphic comparison of the density of the Macoma balthica standing stock during comprehensive surveys. Hatched areas indicate regions receiving maximum exposure to excess temperatures and whose data were not used in model derivation.

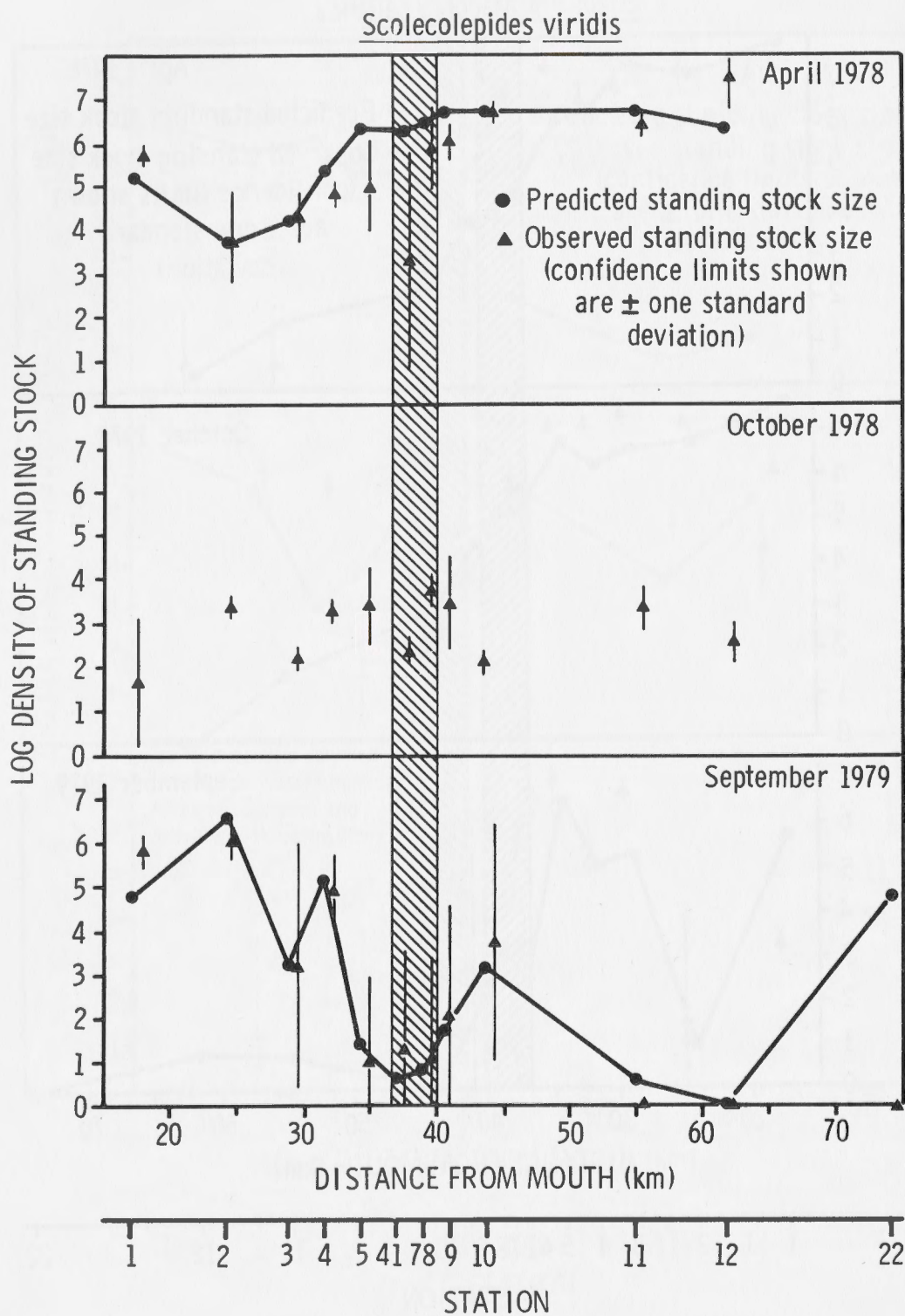


Figure 50. Graphic comparison of the density of the Scolecopides viridis standing stock during comprehensive surveys. Hatched areas indicate regions receiving maximum exposure to excess temperatures and whose data were not used in model derivation.

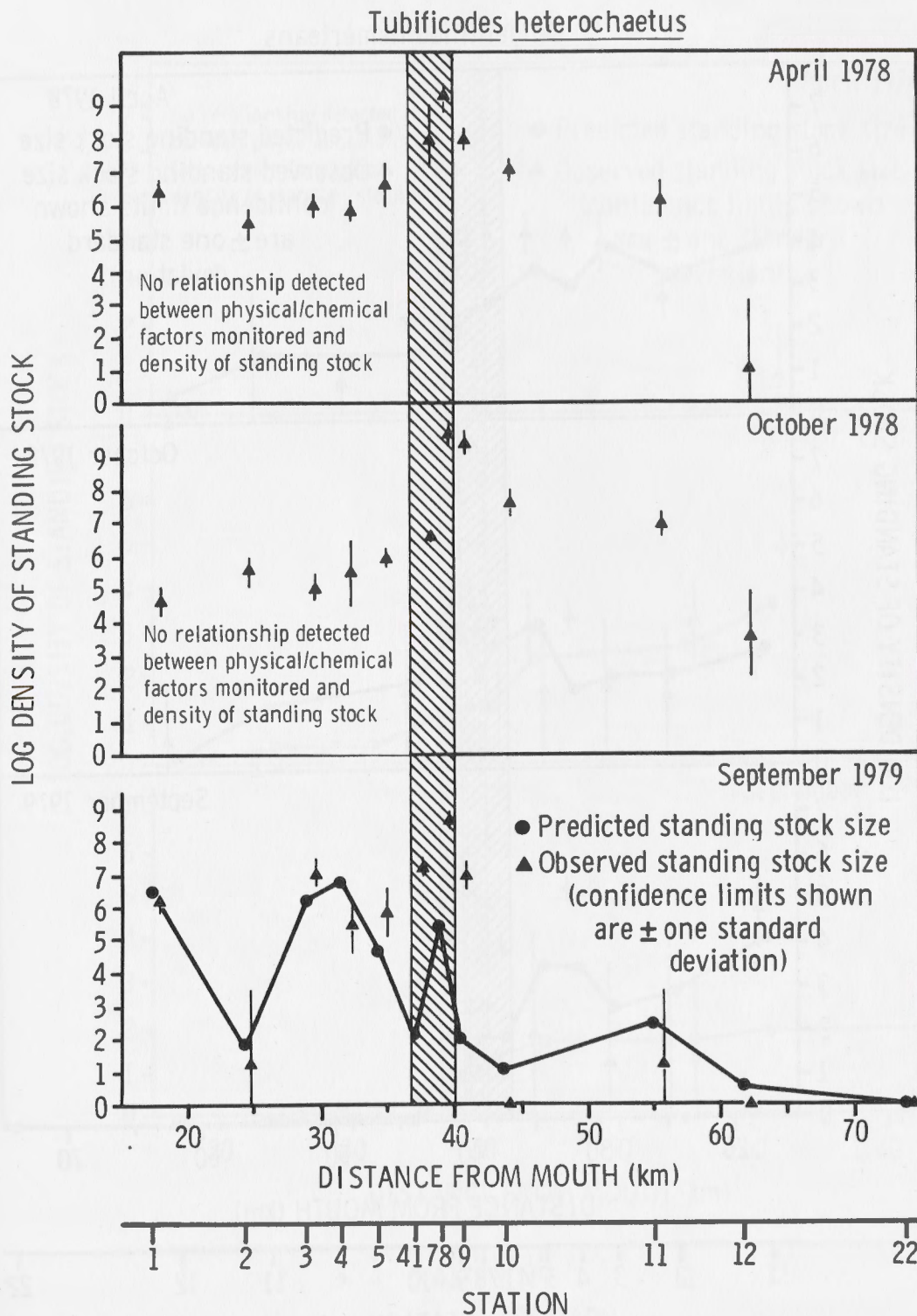


Figure 51. Graphic comparison of the density of the Tubificodes heterochaetus standing stock during comprehensive surveys. Hatched areas indicate regions receiving maximum exposure to excess temperatures and whose data were not used in model derivation.

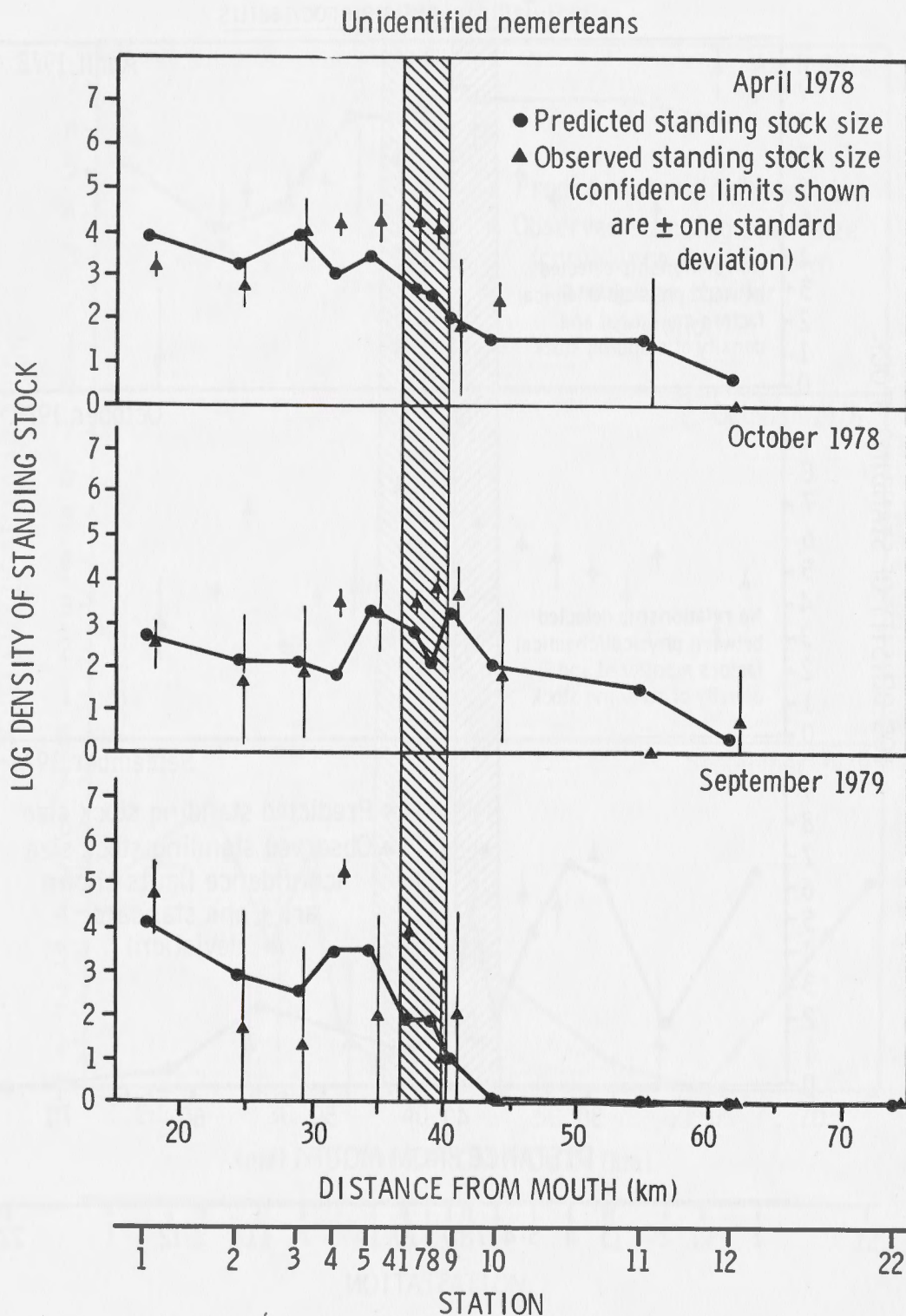


Figure 52. Graphic comparison of the density of the standing stock of unidentified nemerteans during comprehensive surveys. Hatched areas indicate regions receiving maximum exposure to excess temperatures and whose data were not used in model derivation.

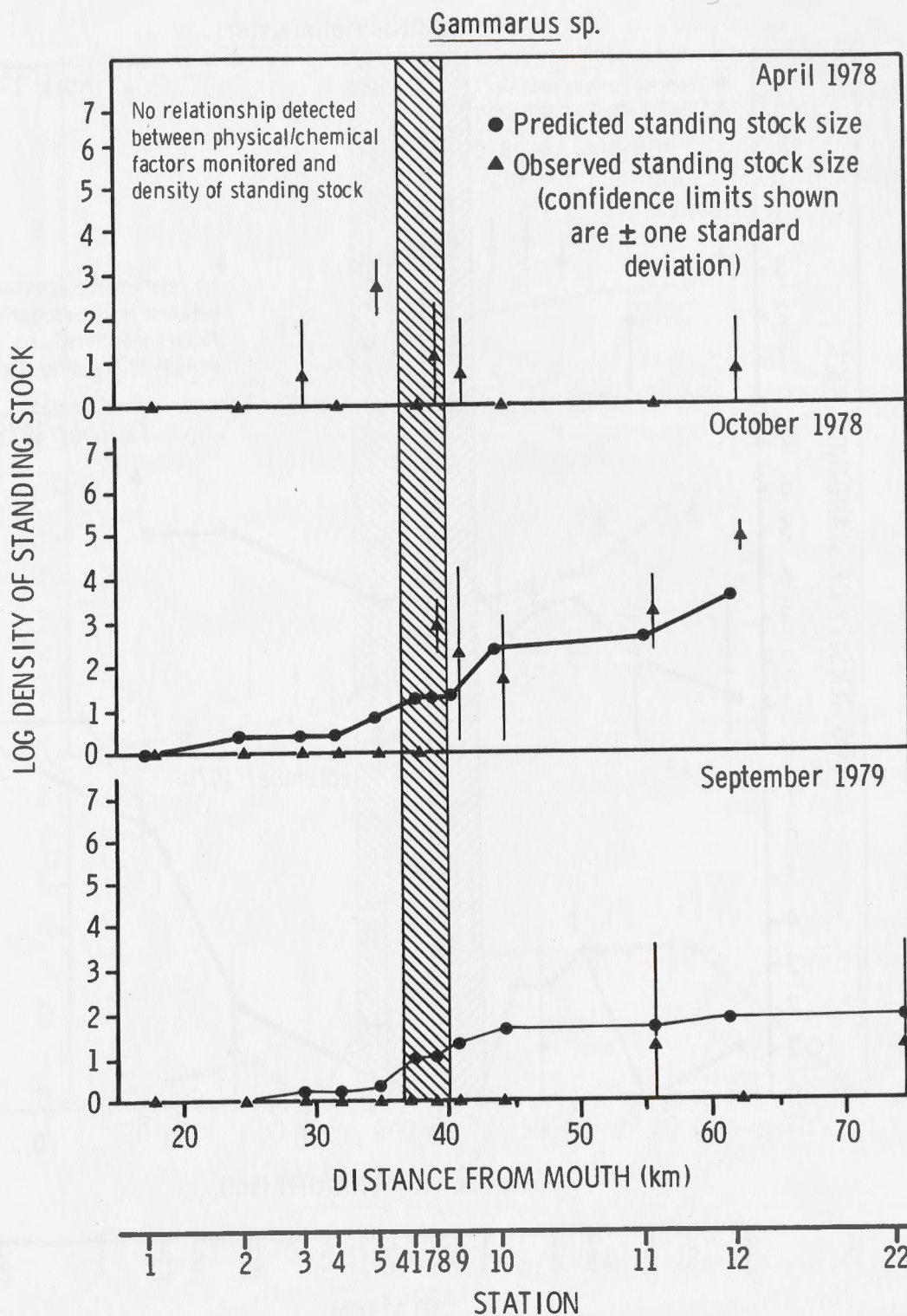


Figure 53. Graphic comparison of the density of the Gammarus sp. standing stock during comprehensive surveys. Hatched areas indicate regions receiving maximum exposure to excess temperatures and whose data were not used in model derivation.

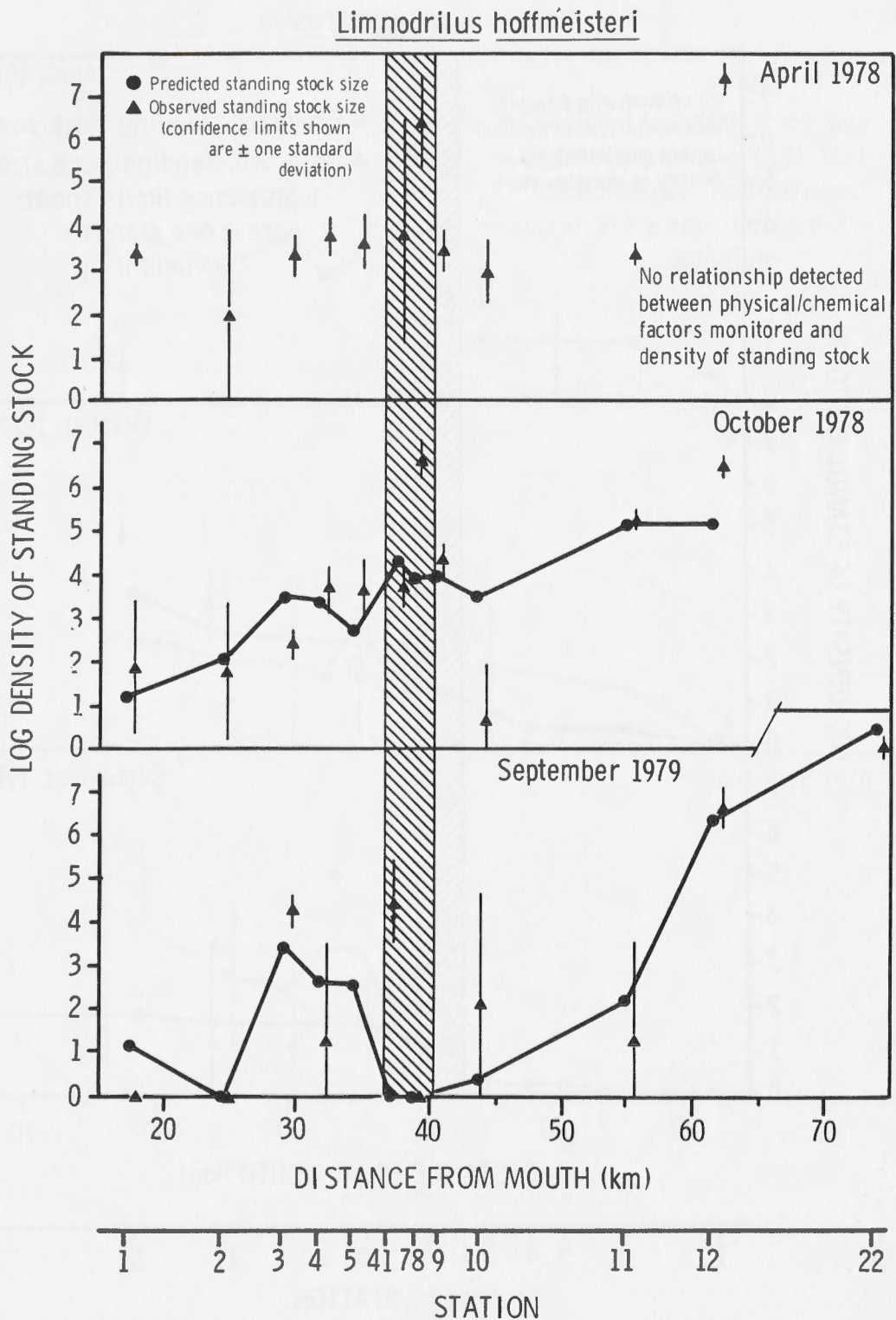


Figure 54. Graphic comparison of the density of the Limnodrilus hoffmeisteri standing stock during comprehensive surveys. Hatched areas indicate regions receiving maximum exposure to excess temperatures and whose data were not used in model derivation.

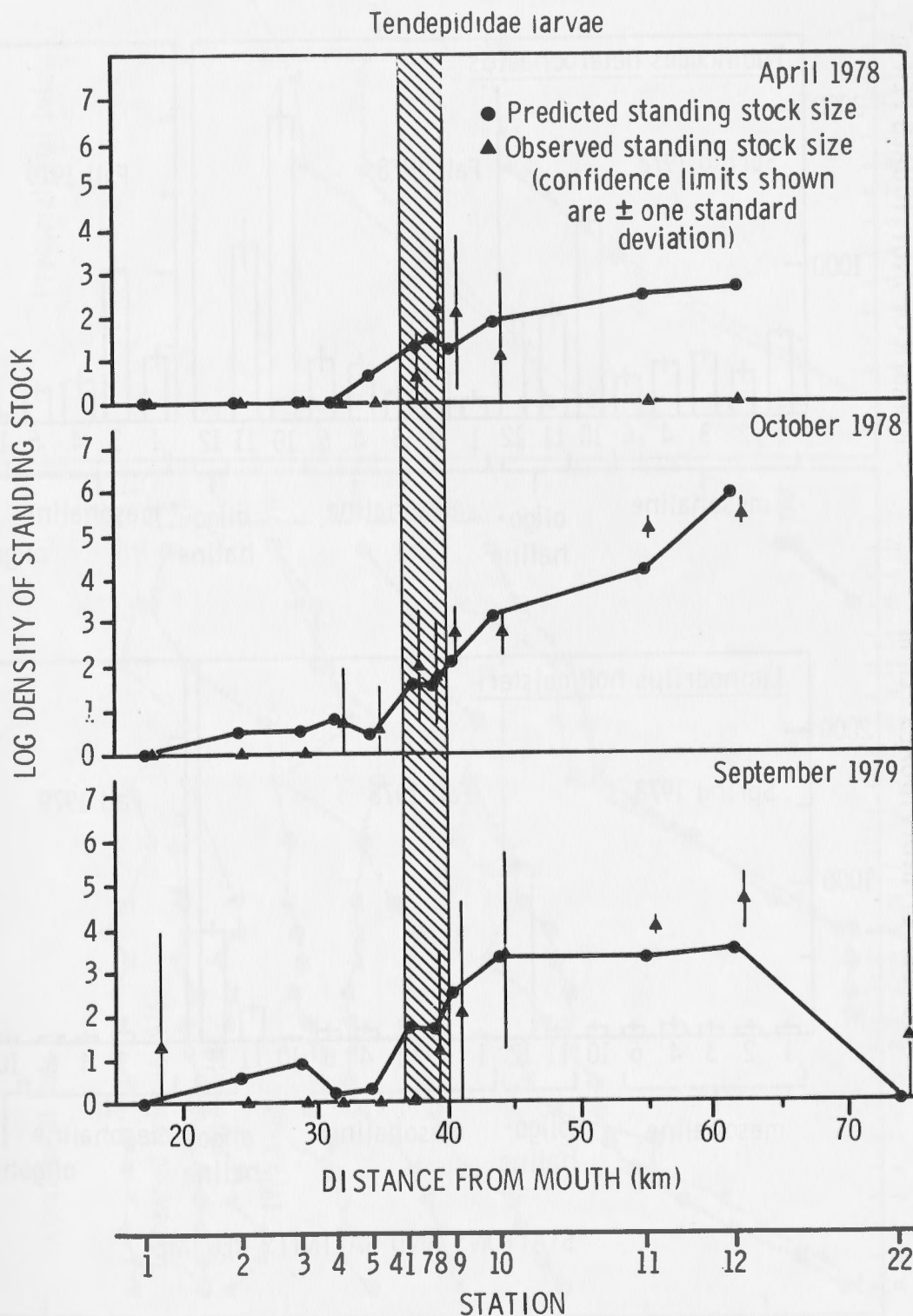


Figure 55. Graphic comparison of the density of the standing stock of Tendipedidae larvae during comprehensive surveys. Hatched areas indicate regions receiving maximum exposure to excess temperatures and whose data were not used in model derivation.

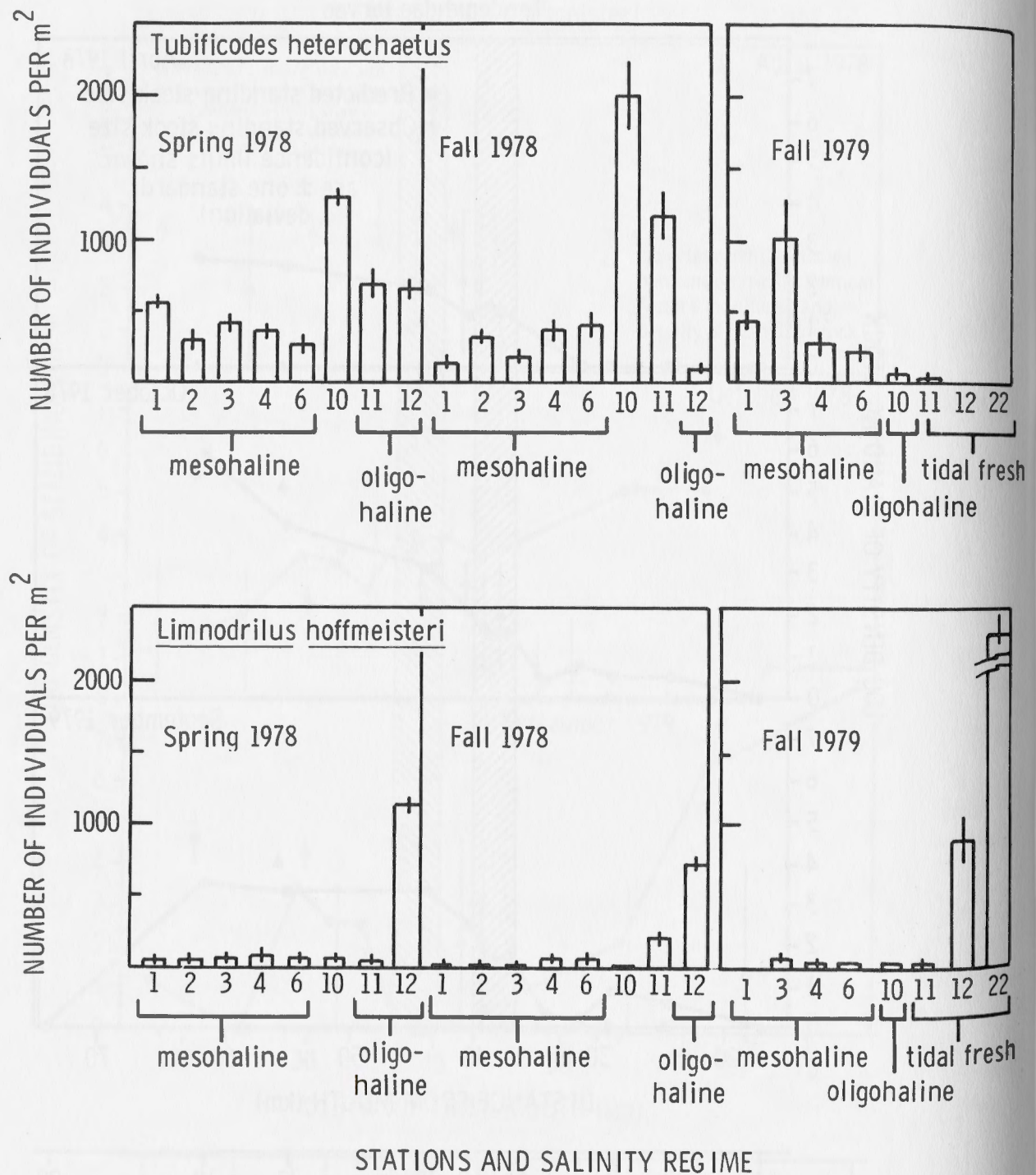


Figure 56. Spatial distribution of the oligochaetes, *Tubificodes heterochaetus* and *Limnodrilus hoffmeisteri*, along the Patuxent estuary during the comprehensive surveys (excluding stations receiving maximum exposure to thermal discharges). Confidence limits are ± 1 standard error.

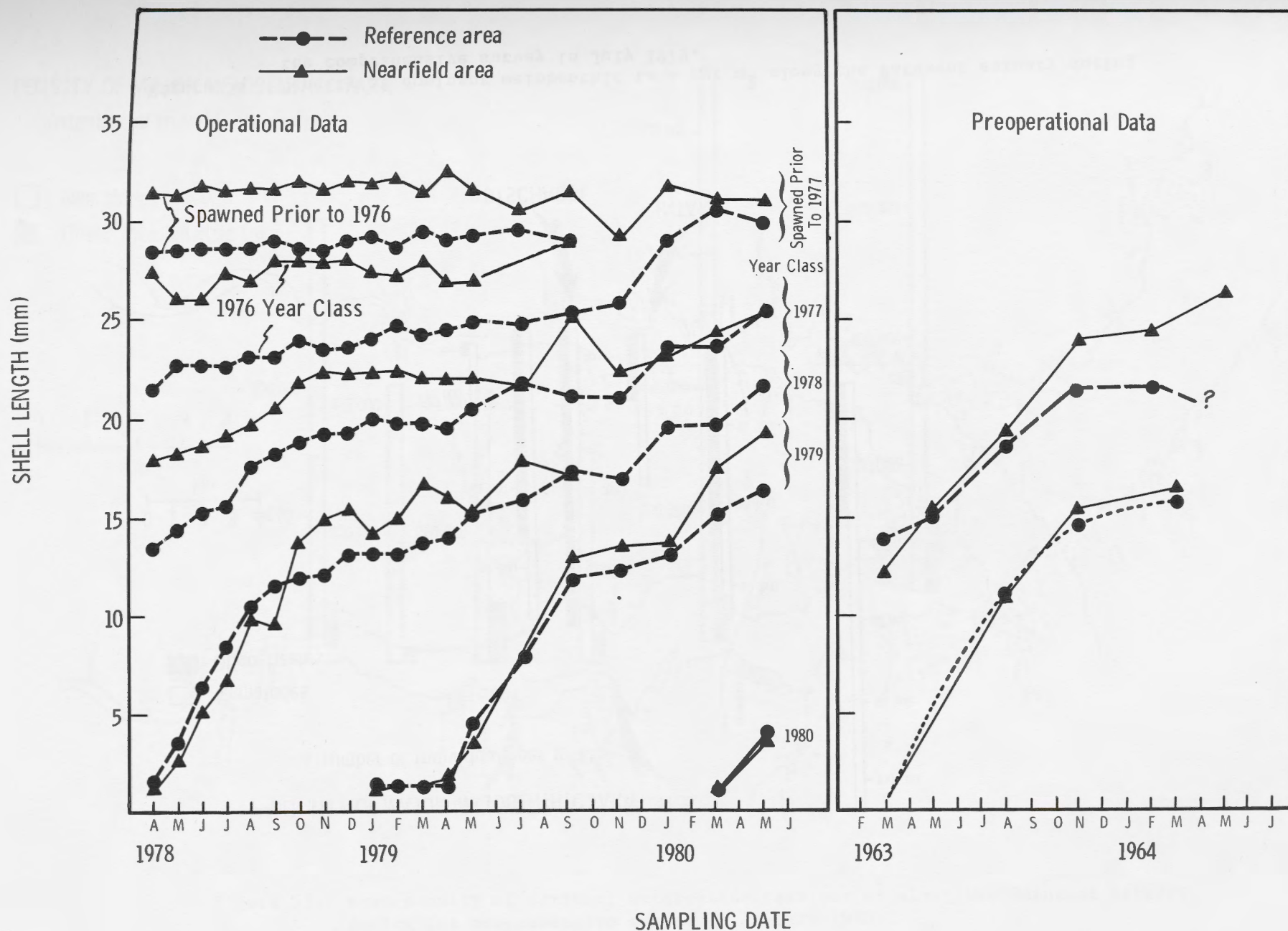


Figure 57. Temporal changes in shell length of various age classes of *Macoma balthica* during the 1978 through 1980 surveys and the preoperational period. Preoperational data from McErlean (1964).

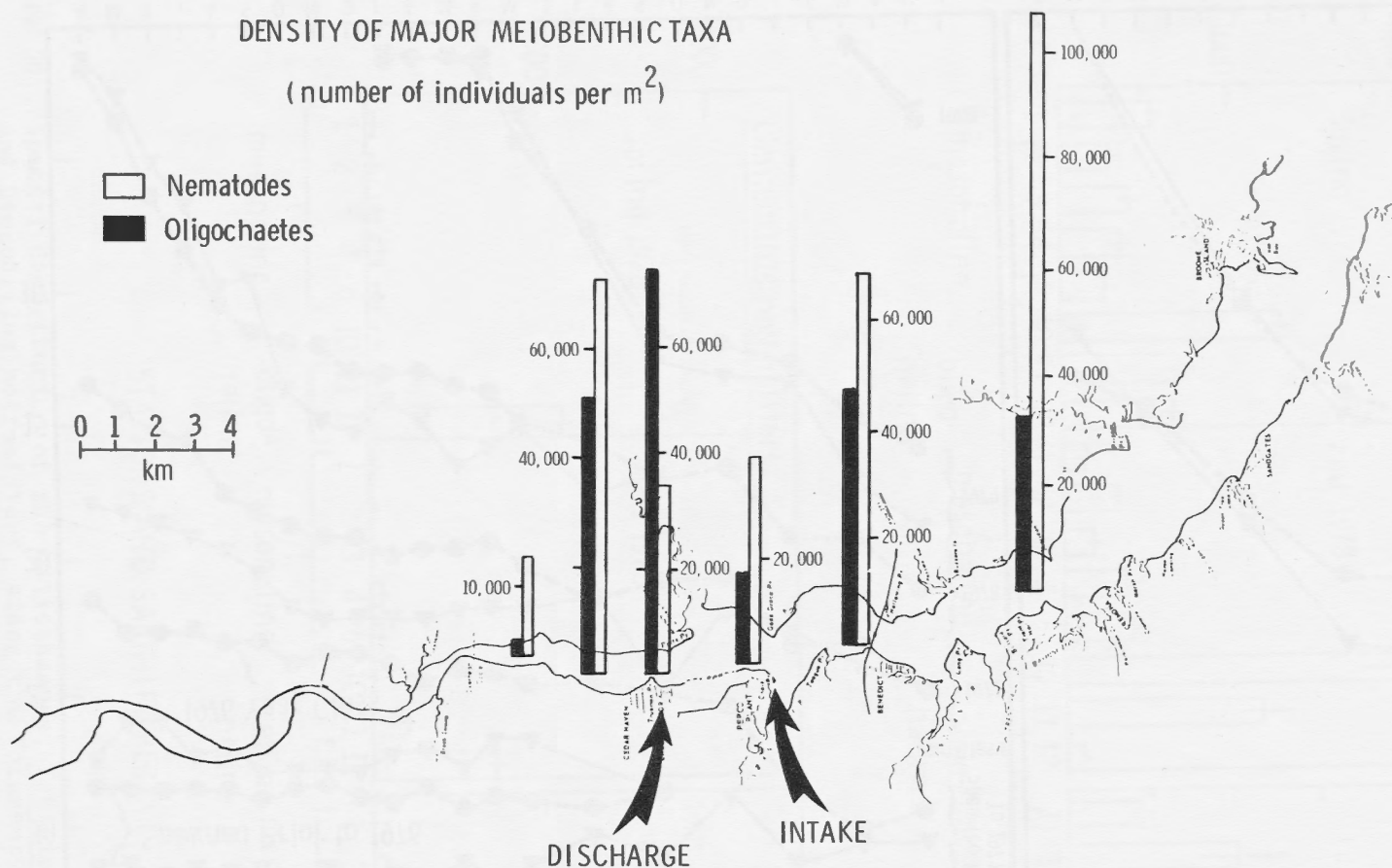


Figure 58. Density of dominant meiobenthic taxa per m² along the Patuxent estuary during the comprehensive survey in July 1979.

DENSITY OF MAJOR MEIOBENTHIC TAXA
(number of individuals per m^2)

□ Nematodes

■ Other Meiobenthic taxa

0 1 2 3 4
km

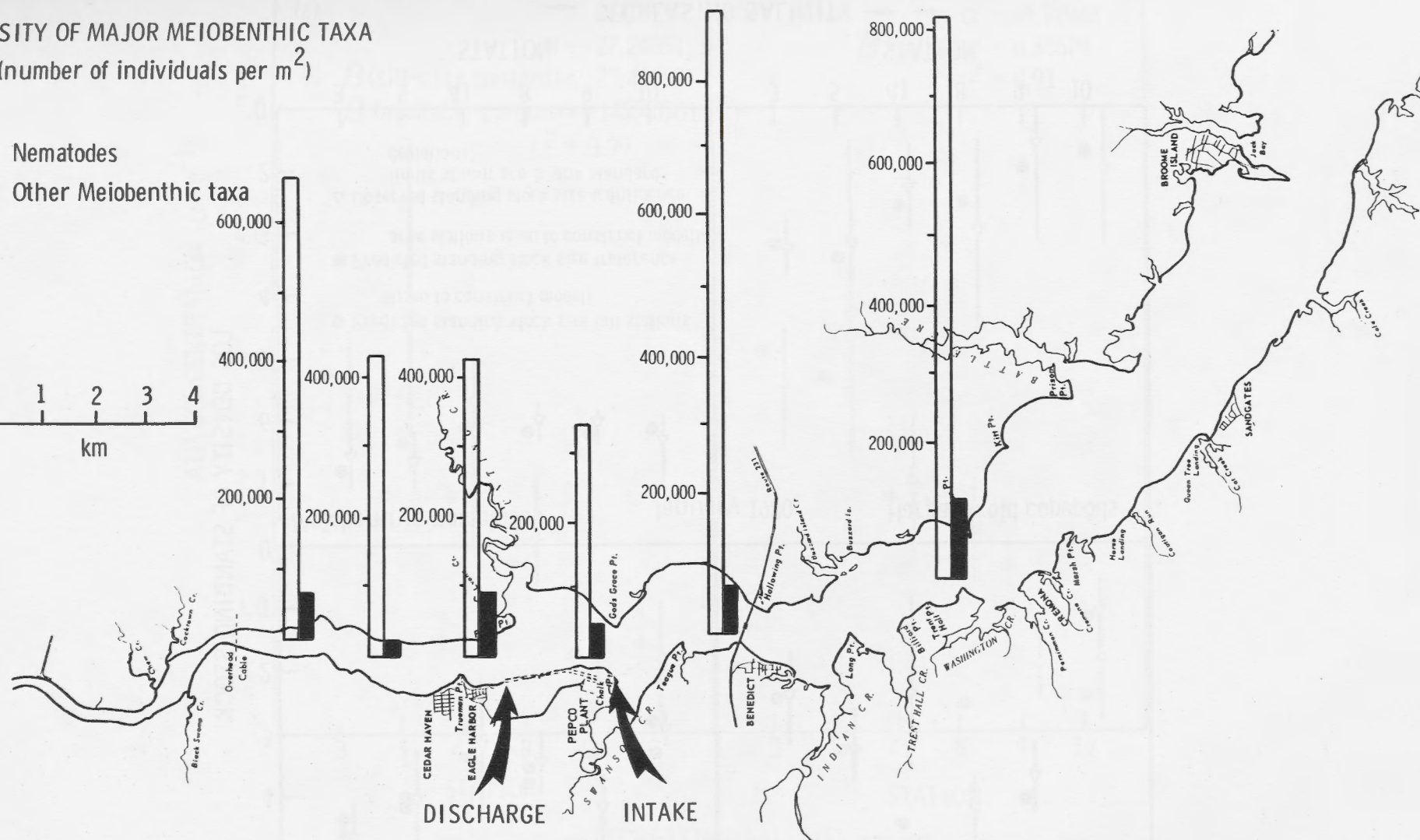


Figure 59. Mean density of dominant meiobenthic taxa per m^2 along the Patuxent estuary during the comprehensive survey in January 1980.

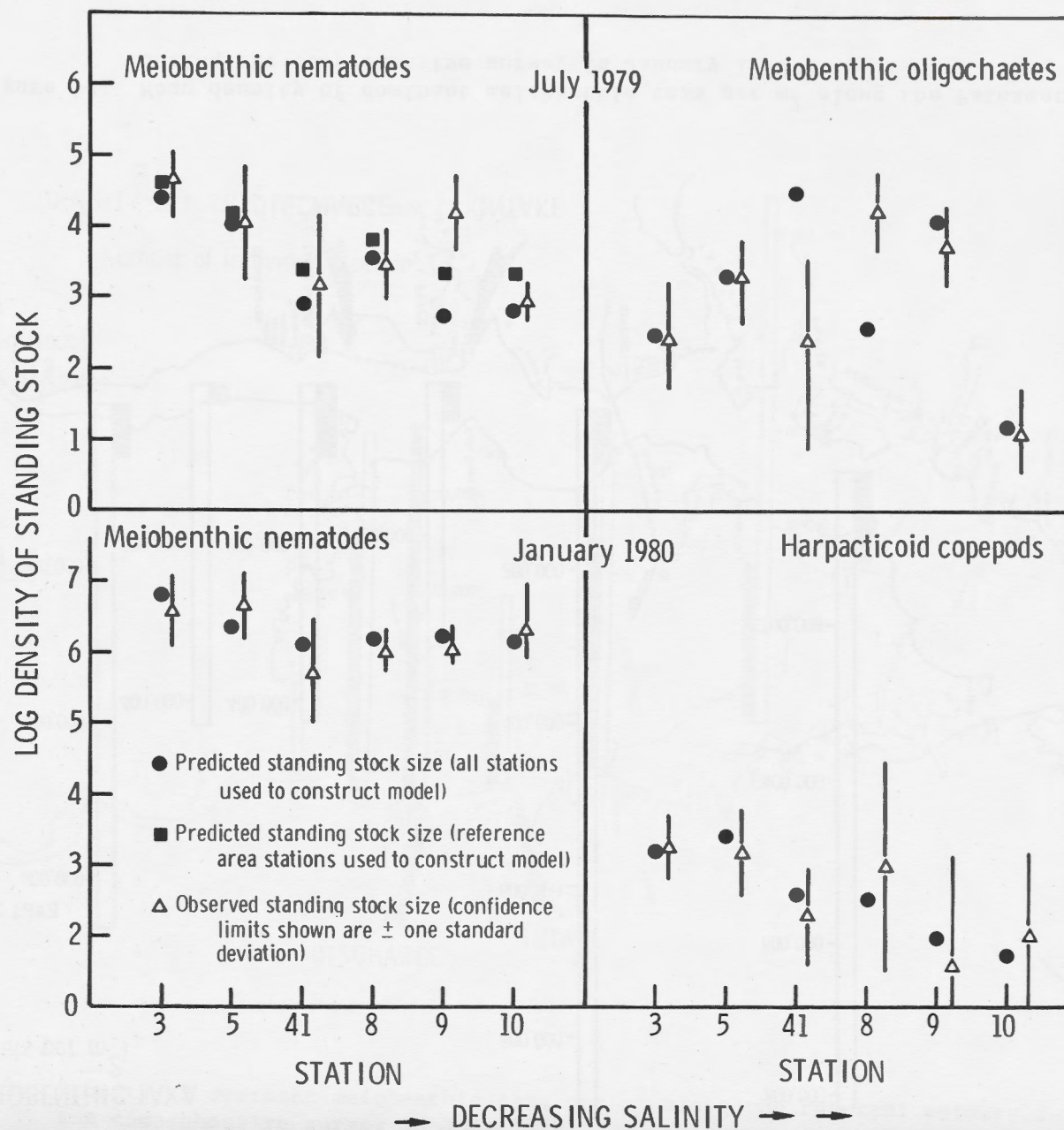


Figure 60. Comparisons of predicted and observed standing stocks for dominant meiobenthic taxa during two comprehensive surveys.

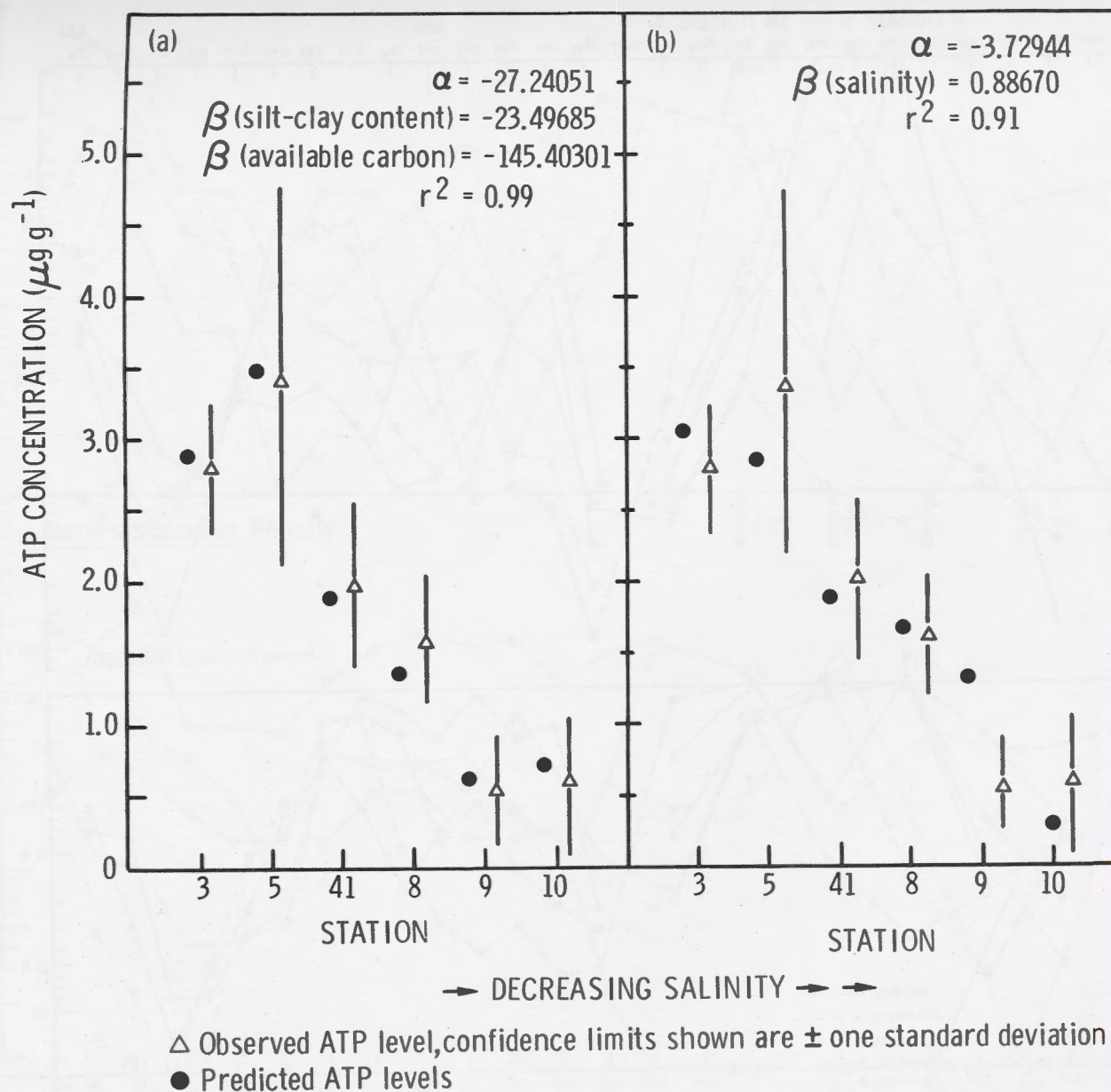


Figure 61. Comparisons of predicted and observed ATP levels in sediments using regression equations based on (a) all the physical/chemical factors monitored and (b) only salinity measurements.

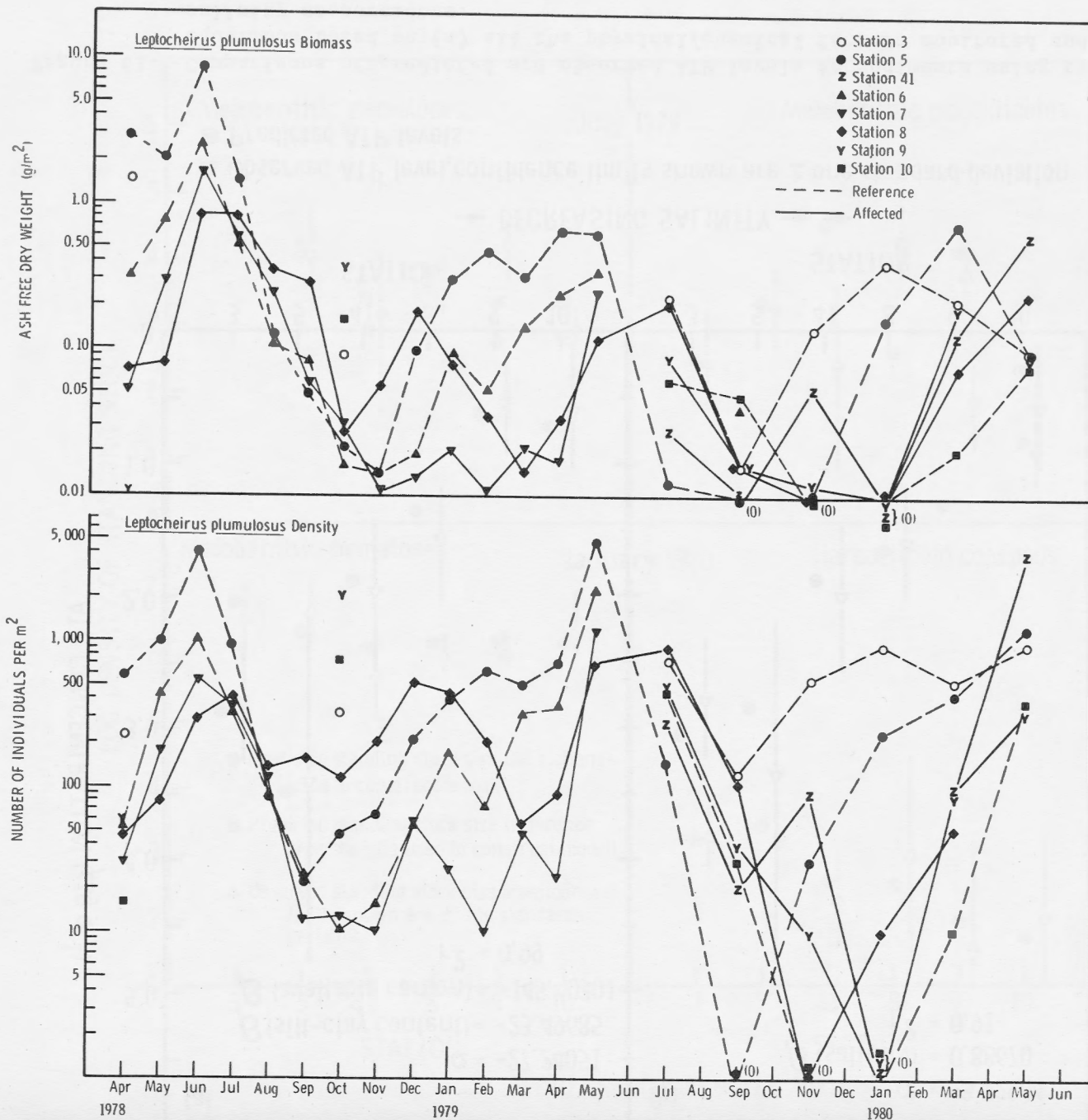


Figure 62. Temporal variation in stocks of Leptocheirus plumulosus at sampling stations near the Chalk Point SES.

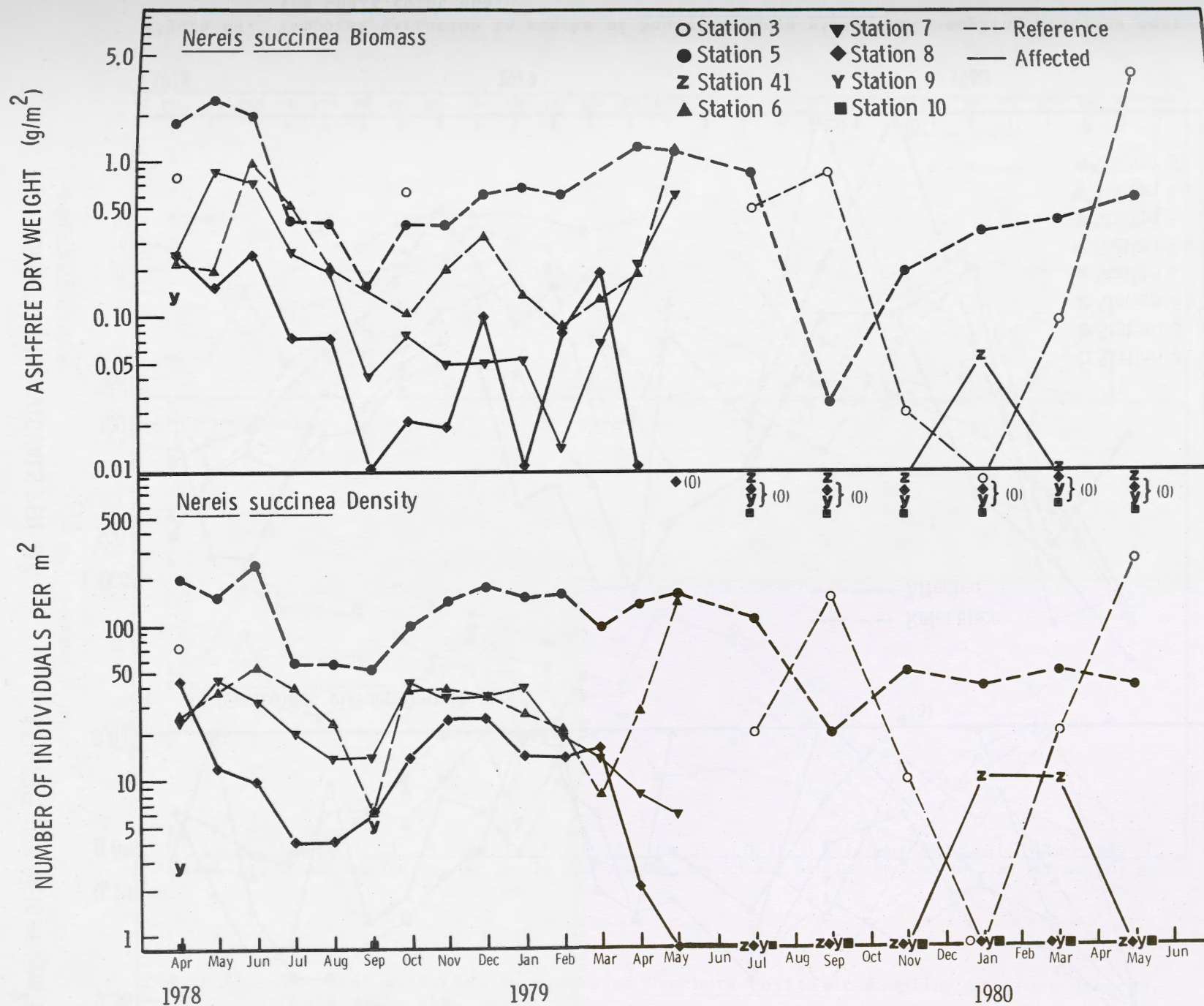


Figure 63. Temporal variation in stocks of *Nereis succinea* at sampling stations near the Chalk Point SES.

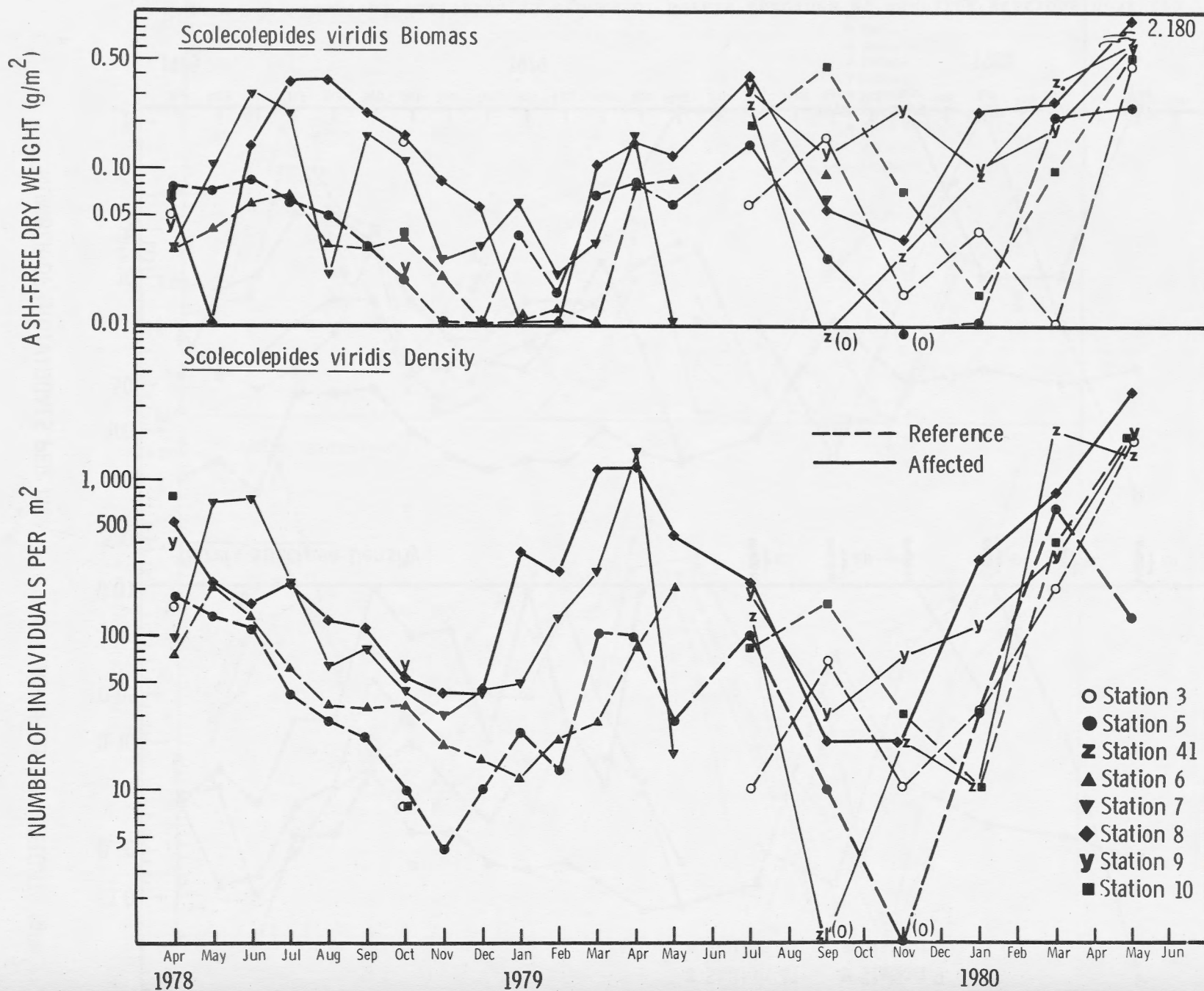


Figure 64. Temporal variation in stocks of *Scoliolepidus viridis* at sampling stations near the Chalk Point SES.

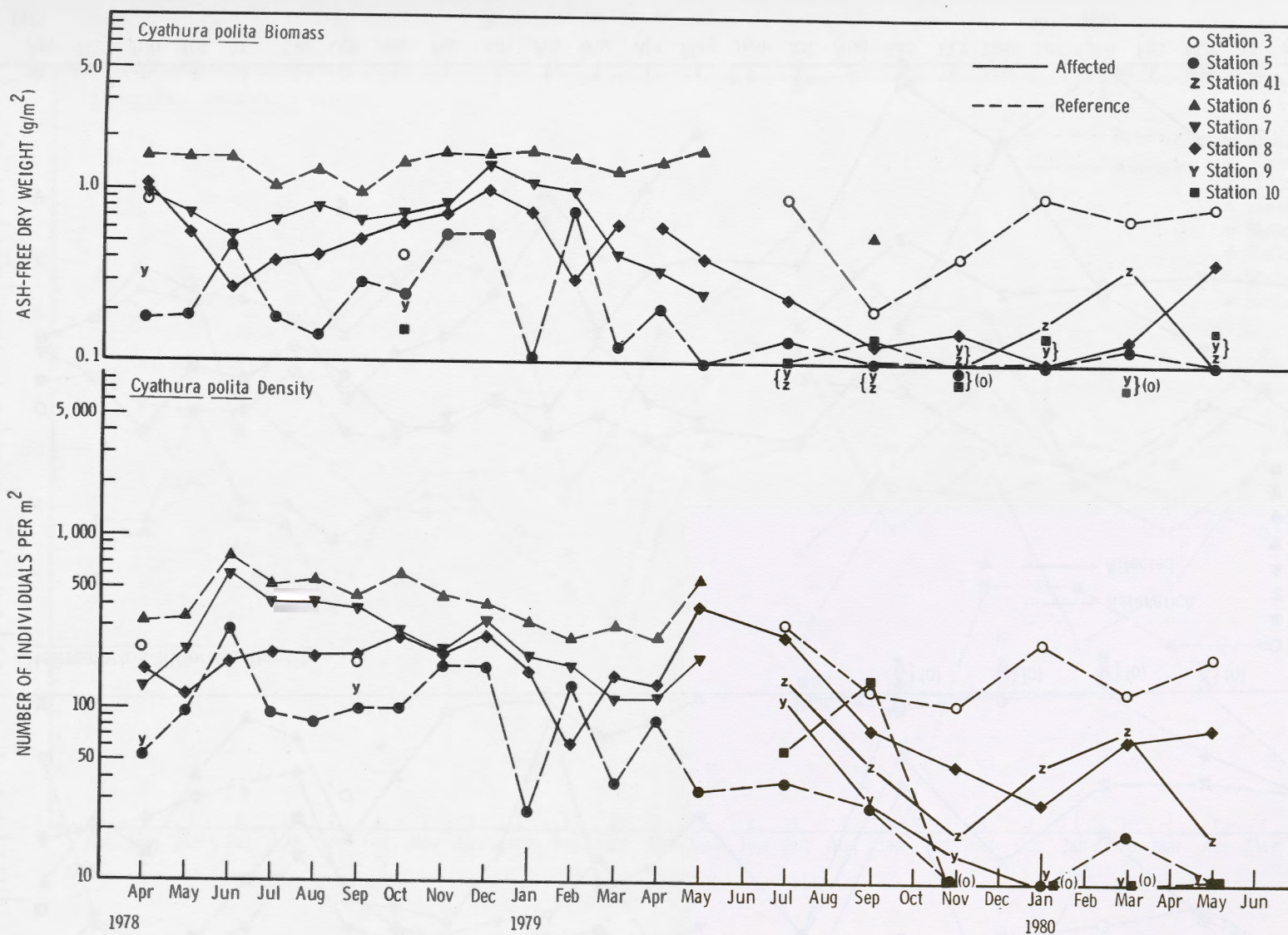


Figure 65. Temporal variation in stocks of *Cyathura polita* at sampling stations near the Chalk Point SES.

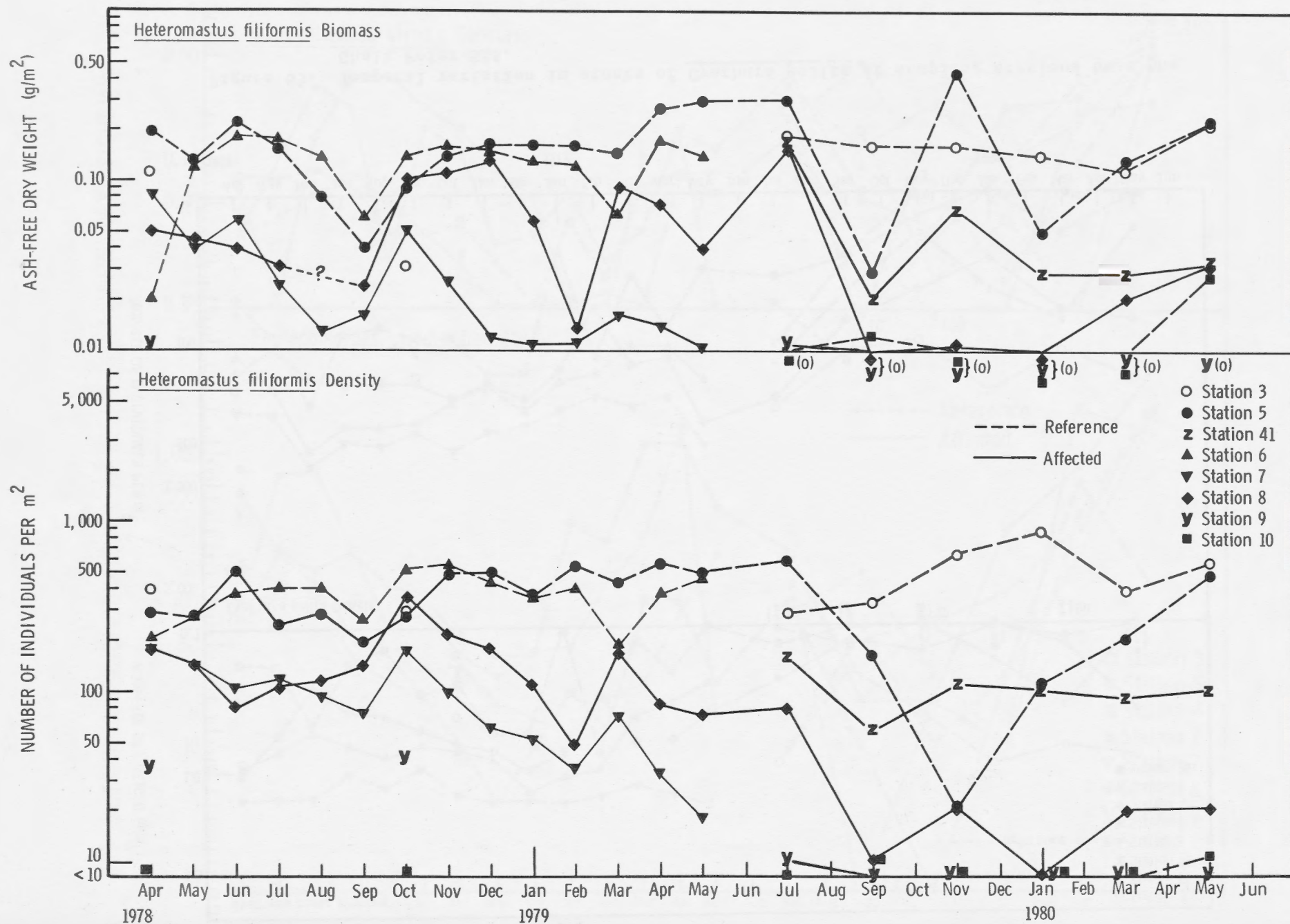


Figure 66. Temporal variation in stocks of *Heteromastus filiformis* at sampling stations near the Chalk Point SES.

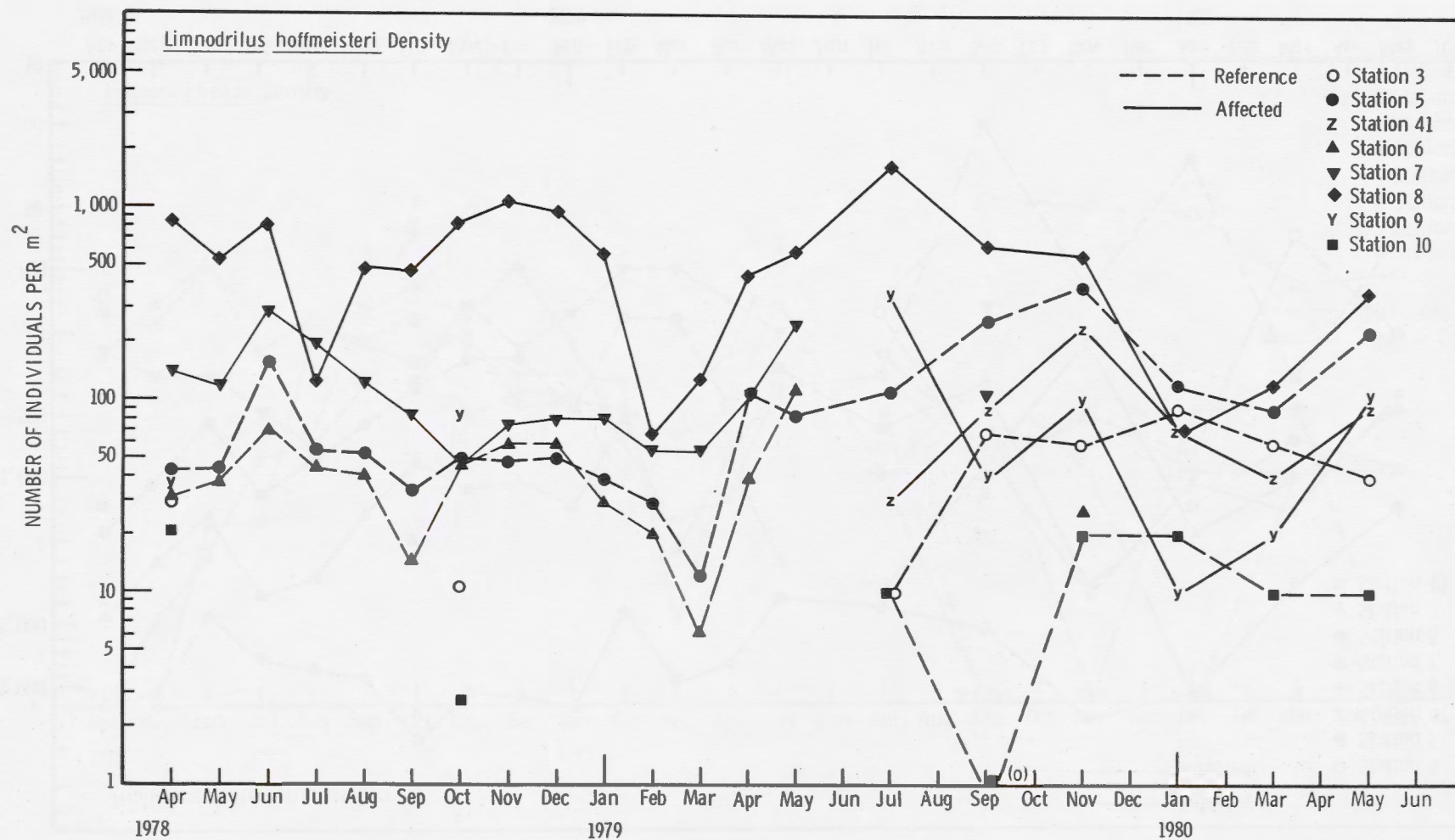


Figure 67. Temporal variation in densities of Limnodrilus hoffmeisteri at sampling stations near the Chalk Point SES.

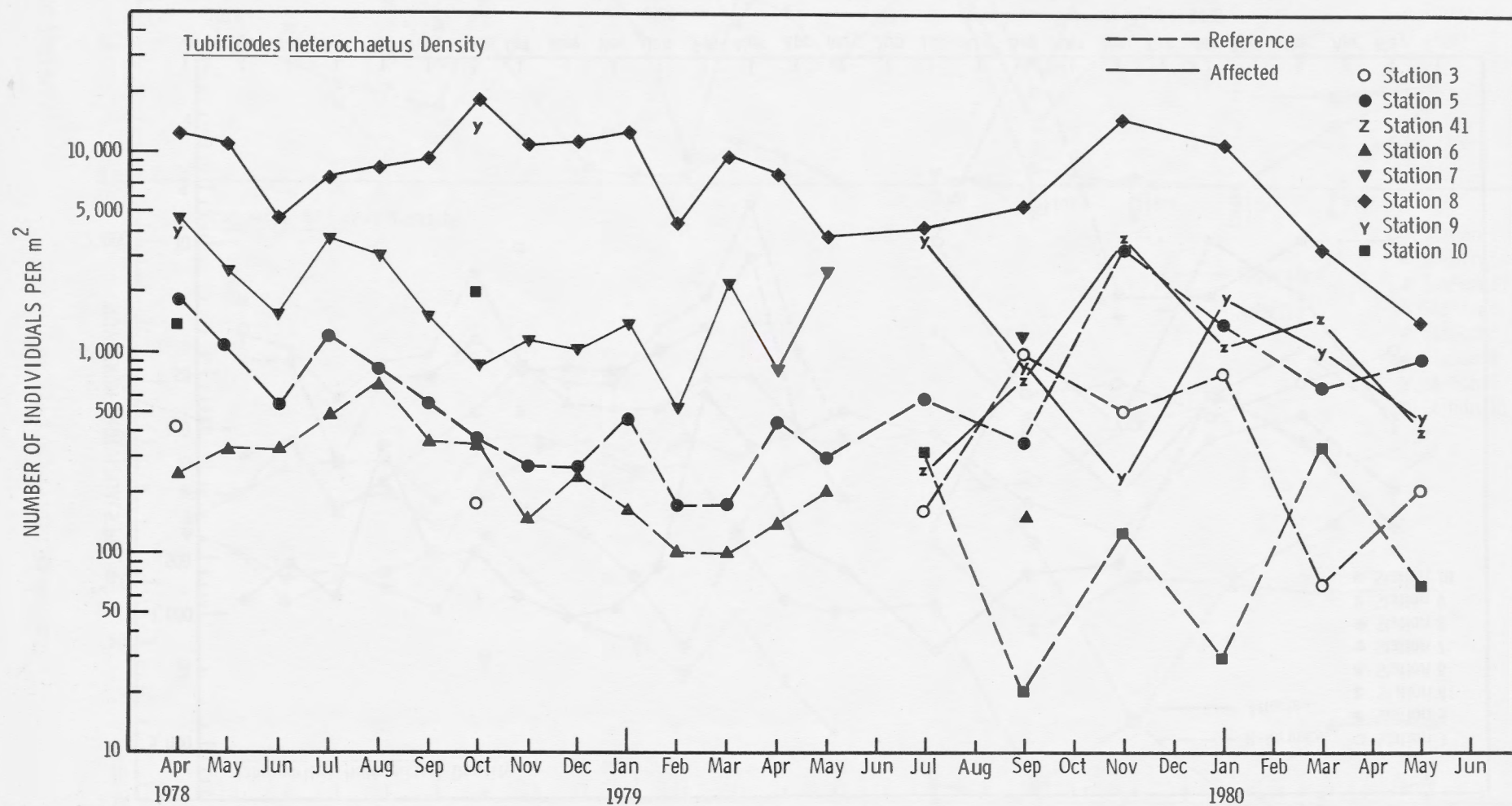


Figure 68. Temporal variation in densities of Tubificodes heterochaetus at sampling stations near the Chalk Point SES.

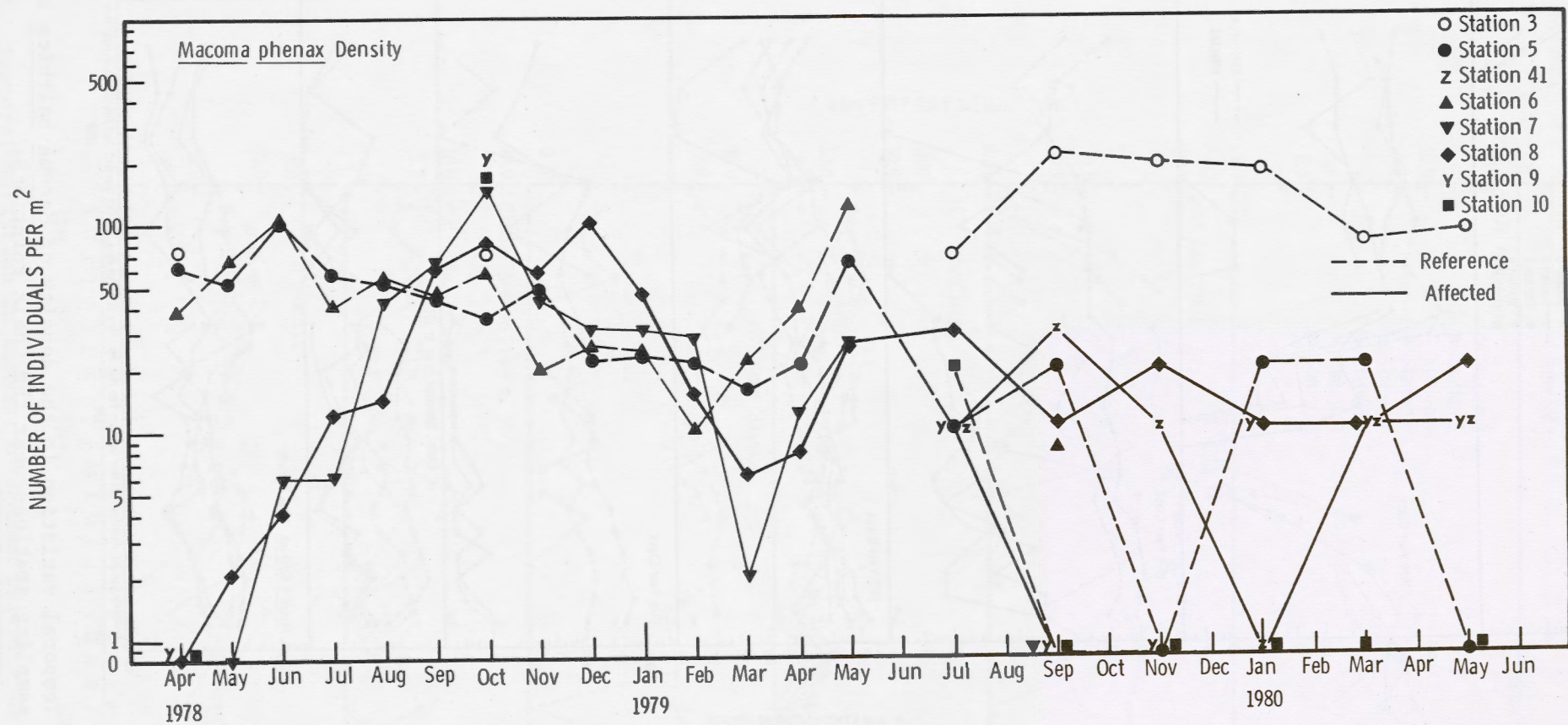


Figure 69. Temporal variation in densities of *Macoma phenax* at sampling stations near the Chalk Point SES.

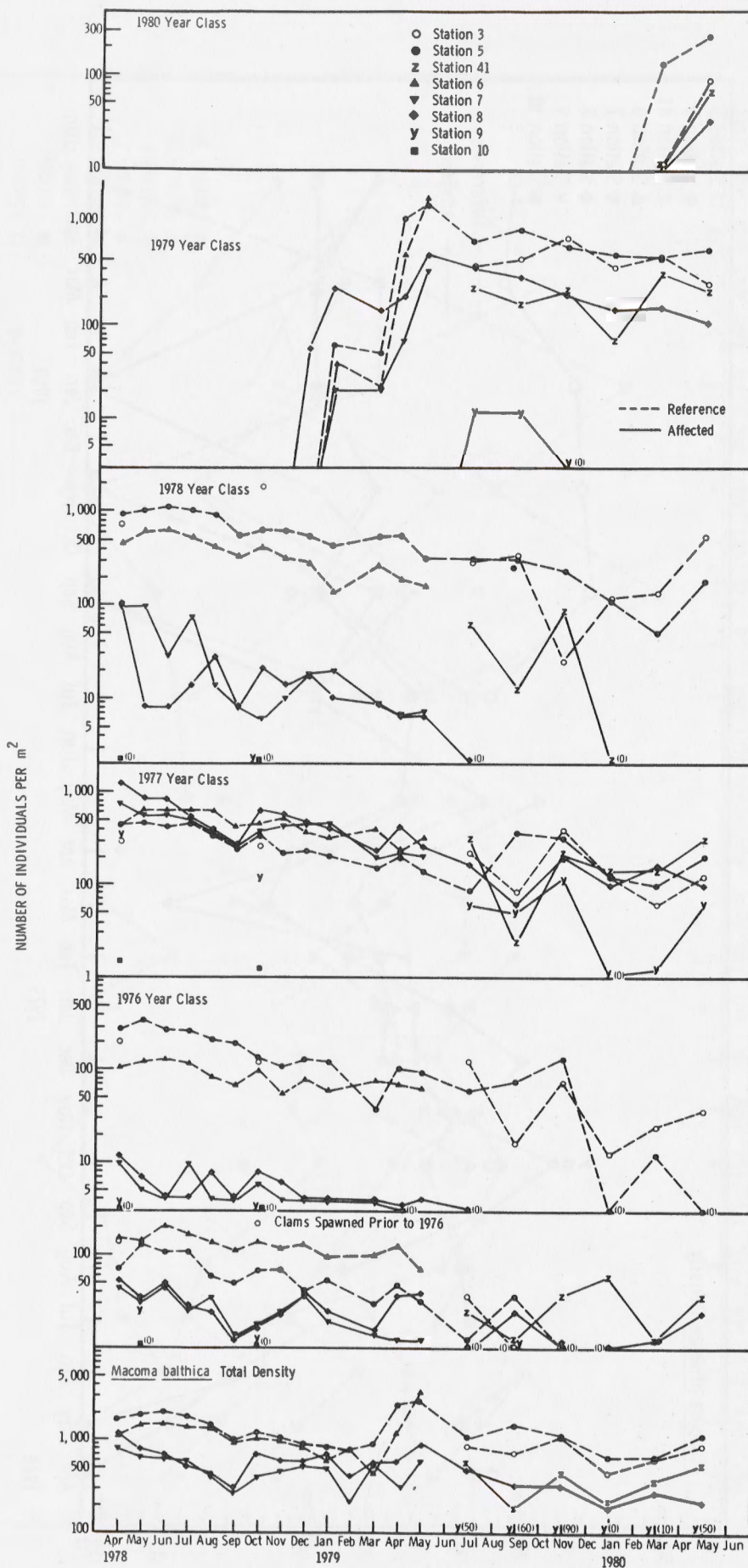


Figure 70. Temporal variation in the density of *Macoma balthica* by age class at sampling stations near the Chalk Point SES.

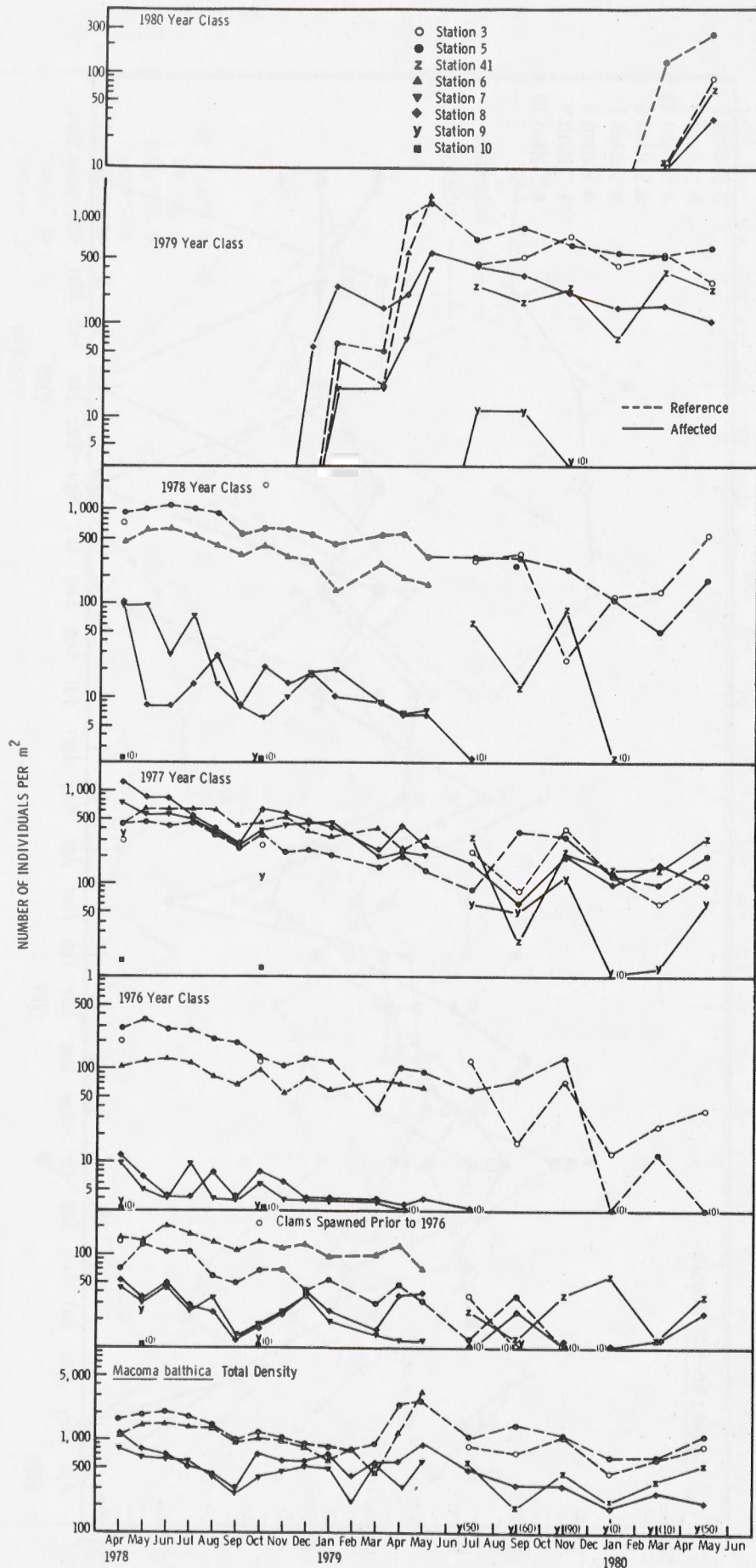


Figure 70. Temporal variation in the density of *Macoma balthica* by age class at sampling stations near the Chalk Point SES.

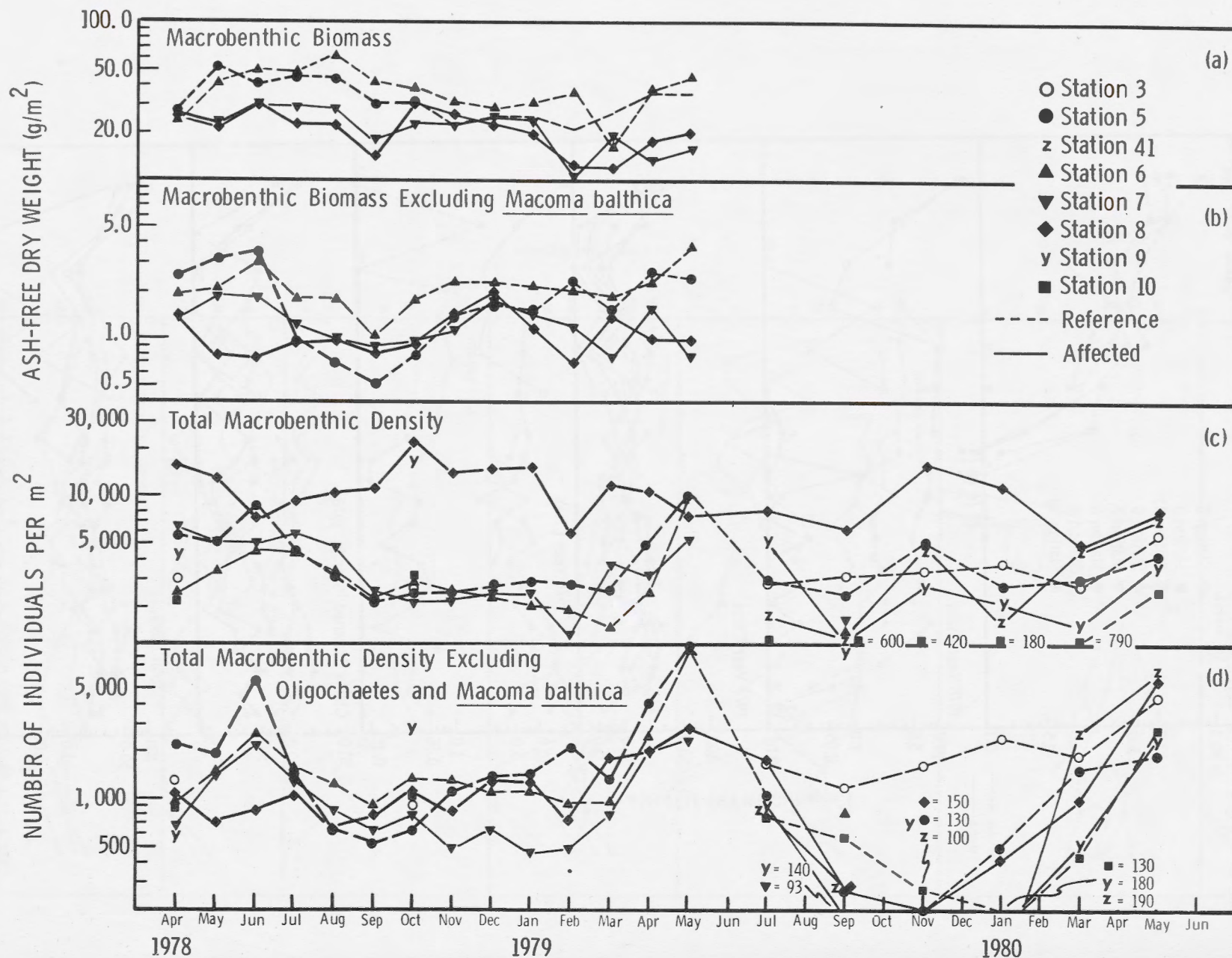


Figure 72. Temporal patterns in total benthic community characteristics at sampling stations near the Chalk Point SES.

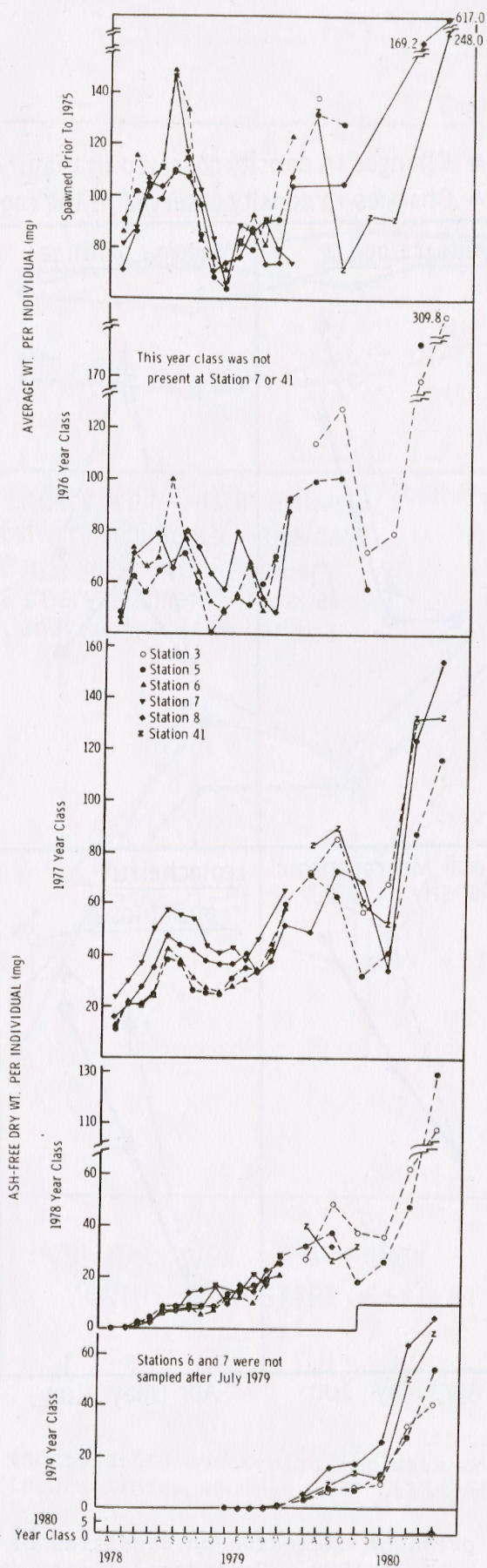


Figure 73. Variation in the ash-free dry weight for individual *Macoma balthica*.

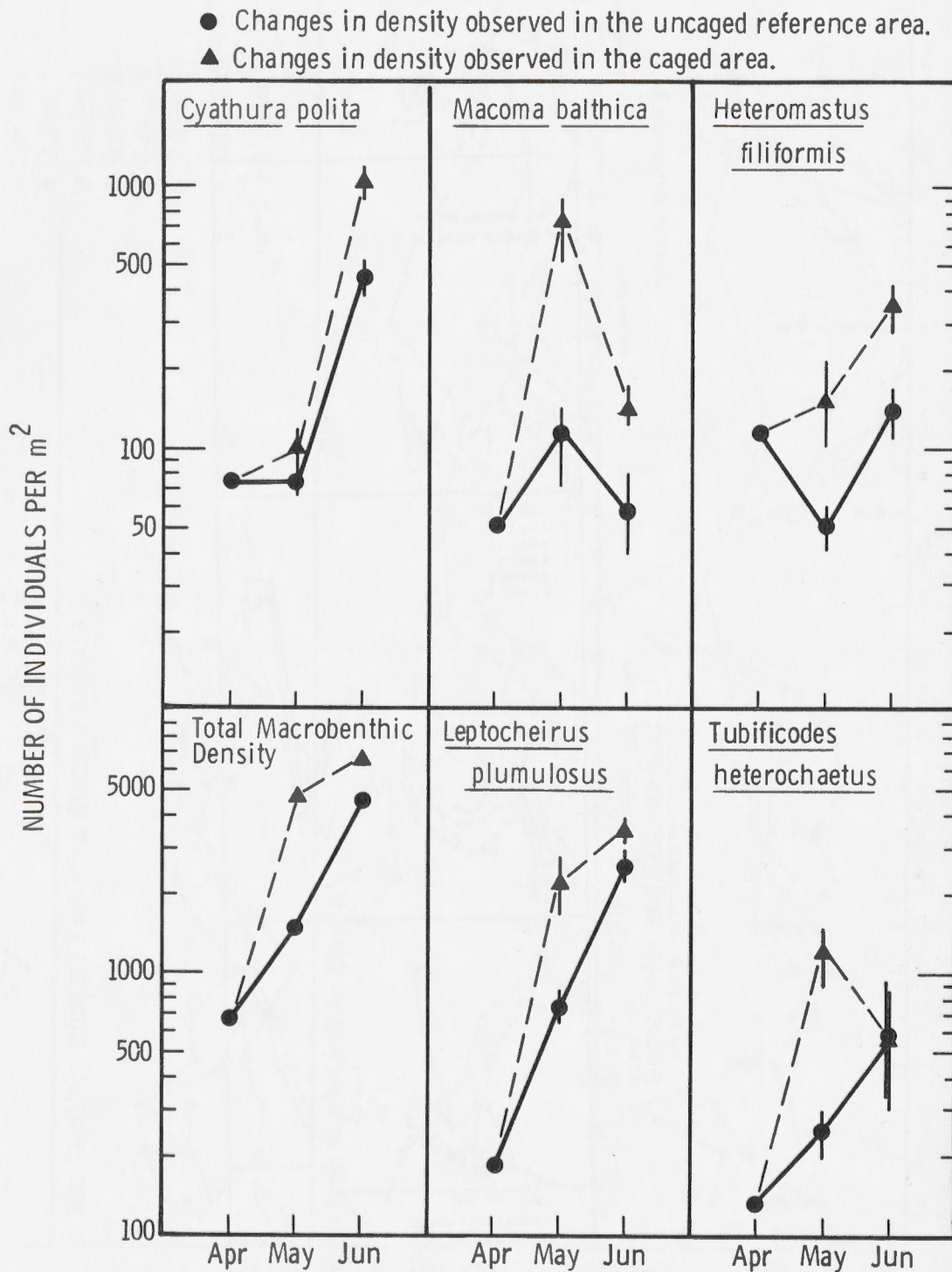


Figure 74. Effects of predator exclusion on densities of macrobenthic organisms from April to June 1978. Confidence limits shown are ± 1 standard error.

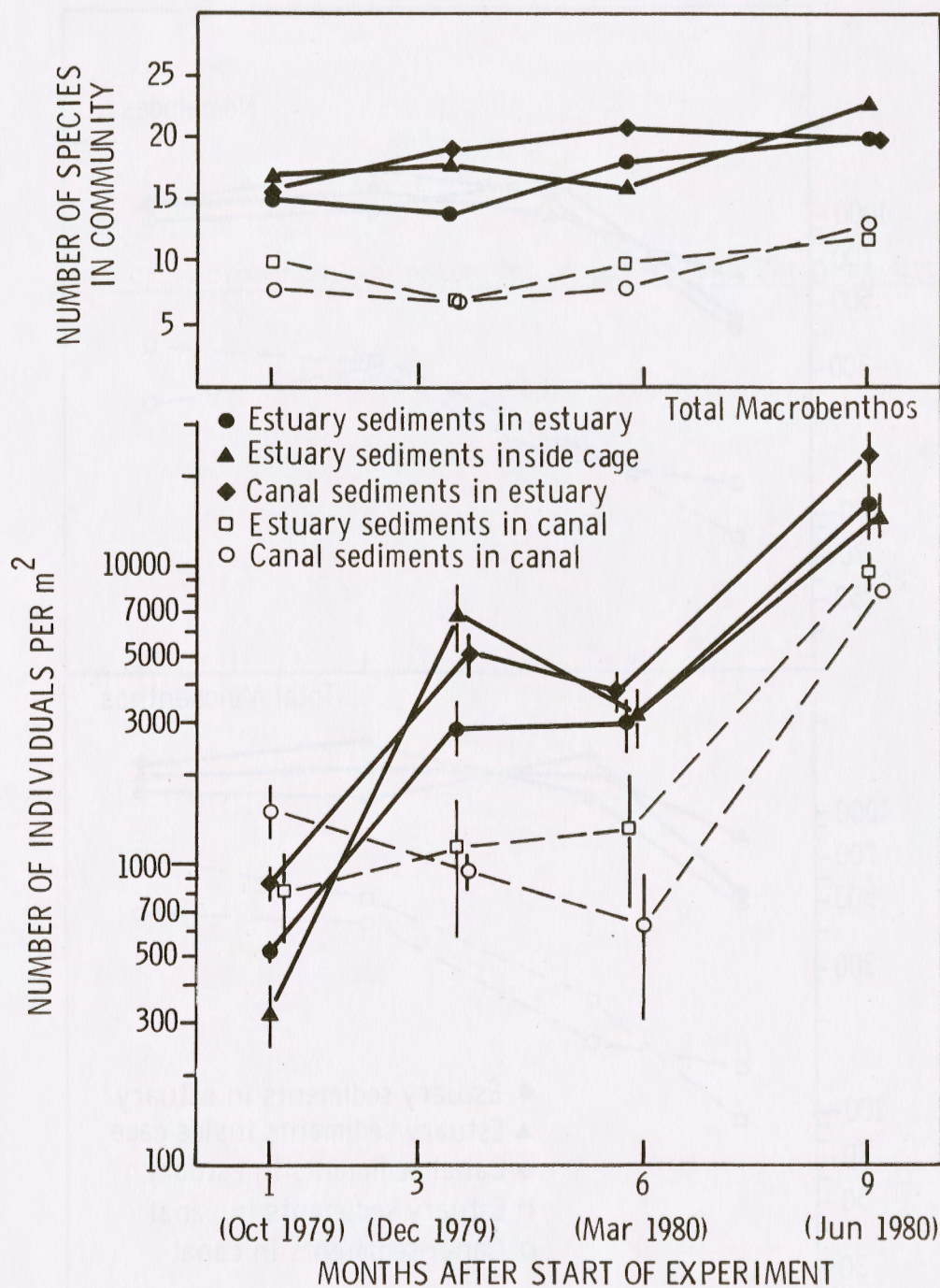


Figure 75. Summary of macrobenthic recolonization data collected during 1979 and 1980. Confidence limits shown are ± 1 standard error.

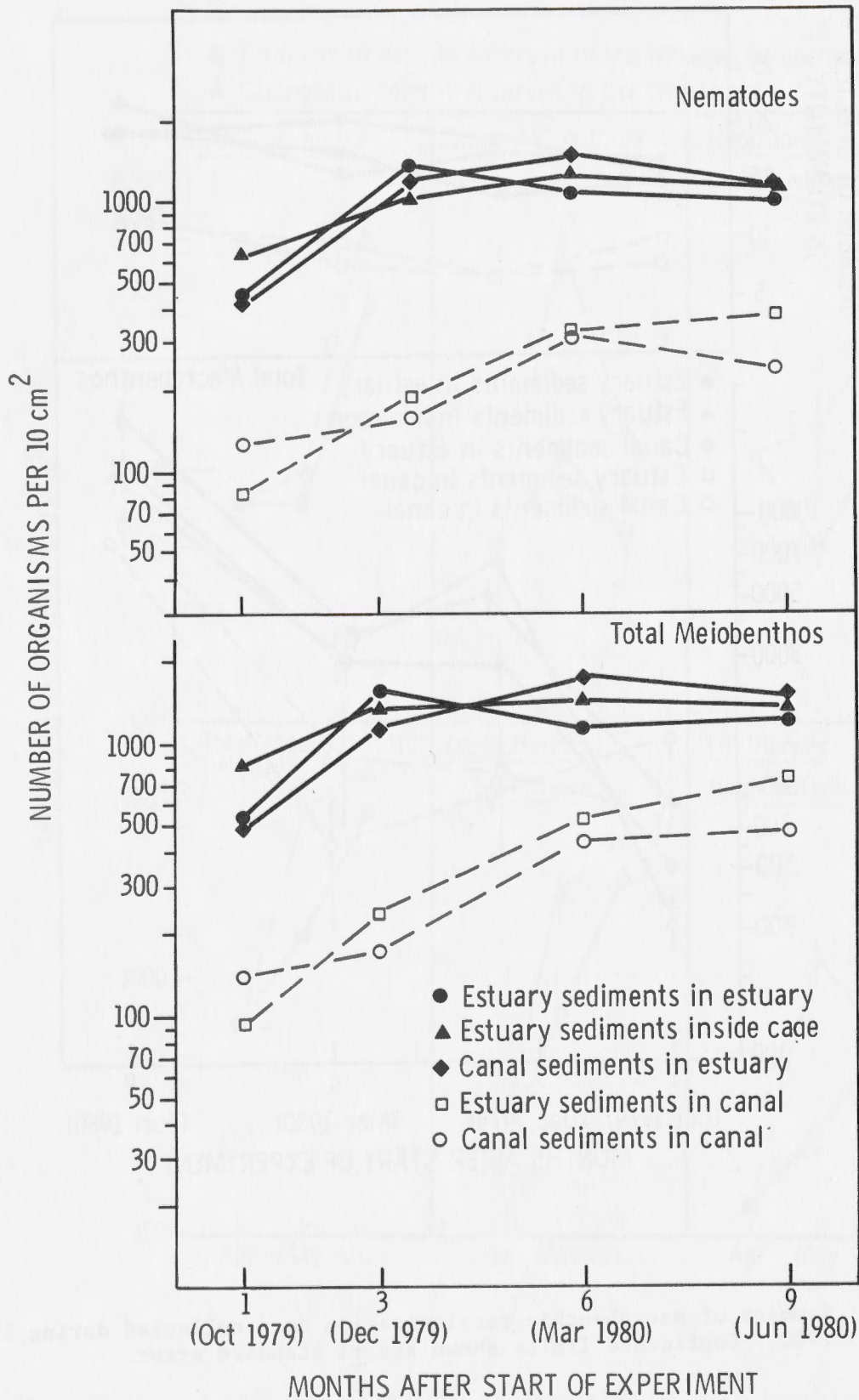


Figure 76. Summary of meiobenthic recolonization data collected during 1979 and 1980.

APPENDIX A

List of Macrobenthic Species Occurring in the Patuxent Estuary

APPENDIX ASpecies List of Macrobenthic Species Occurring in the Patuxent Estuary

All species listed are benthic macroinvertebrates recorded from the Patuxent estuary or presumed to occur there because of their known distributions in environmentally similar regions of the Chesapeake Bay. This list does not exclude the possibility that species other than those listed may occur in the Patuxent. Identifications made only to genera may or may not be the same species already listed under the generic name. For a comprehensive list of free-living invertebrates in tidal fresh, oligohaline, mesohaline, and near polyhaline waters of the Chesapeake Bay, see Wass (1972).

Reference numbers in the last column correspond to the reference list following the table. References numbered with a superscript a possibly may have incorrectly identified the species.

Key

—————	General distribution and salinity range
-----	Marginal distribution and salinity range
*	Species found in this study

LIST OF BENTHIC
MACROINVERTEBRATES
RECORDED FROM
THE PATUXENT ESTUARY

LIST OF BENTHIC MACROINVERTEBRATES RECORDED FROM THE PATUXENT ESTUARY	Salinity Range					Habitat Type					Feeding Mode					Reproduction					Reference Number	
	Linnetic	Oligohaline	Mesohaline	Polyhaline	Sand	Silt-Clay	Rooted Aquatics	Fouling	Oyster Beds	Intertidal Flats	Filter-Suspension Feeder	Deposit Feeder	Predator	Scavenger	Planktonic Larvae	Brooded Young	Other (e.g., Asexual)	Season of Reproduction				
																		Winter	Spring	Summer		Fall
PHYLUM PORIFERA																						
Class Demospongiae																						
Order Haplosclerida																						
Family Halicionidae																						
<u>Haliclona canaliculata</u>																						
<u>Haliclona loosanoffi</u>																						
Order Poecilosclerida																						
Family Microcionidae																						
<u>Microciona prolifera</u>																						
Order Hadromerida																						
Family Clionidae																						
<u>Cliona truitti</u>																						

LIST OF BENTHIC
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	Limnetic	Oligohaline	Mesohaline	Polyhaline	Sand	Silt-Clay	Rooted Aquatics	Fouling	Oyster Beds	Intertidal Flats	Filter-Suspension Feeder	Deposit Feeder	Predator	Scavenger	Planktonic Larvae	Brooded Young	Other (e.g., Asexual)	Season of Reproduction				
																		Winter	Spring		Summer	Fall
PHYLUM CNIDARIA																						
Class Anthozoa																						
Subclass Zoantharia																						
Order Actinaria																						
Family Diadumenidae																						
* <u>Diadumene leucolena</u>																				1,2,3,4,5,13,14,18,27, 34,35,36,38,39,45,55		
Family Edwardsiidae																						
<u>Edwardsia</u> sp. (elegans)																				3,14,27,35,45		
Family Aiptasiomorphidae																						
<u>Haliplanella</u> (<u>Aiptasio-</u> <u>morpha</u>) <u>luciae</u>																				3,14,27,45		
Class Hydrozoa																						
Order Athecata																						
Family Corynidae																						
<u>Sarsia tubulosa</u>																				4,13,14,27,45		

LIST OF BENTHIC
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LIST OF BENTHIC MACROINVERTEBRATES RECORDED FROM THE PATUXENT ESTUARY	Salinity Range					Habitat Type					Feeding Mode					Reproduction					Reference Number	
	Limnetic	Oligohaline	Mesohaline	Polyhaline	Sand	Silt-Clay	Rooted Aquatics	Fouling	Oyster Beds	Intertidal Flats	Filter-Suspension Feeder	Deposit Feeder	Predator	Scavenger	Planktonic Larvae	Brooded Young	Other (e.g., Asexual)	Season of Reproduction				
																		Winter	Spring	Summer		Fall
PHYLUM CNIDARIA (continued)																						
Family Halocordylidae																						
<u>Halocordyle disticha</u> = <u>Pennaria tiarella</u>						•	•	•		•		•		•	•	•				13,14,27,36		
Family Clavidae																						
<u>*Cordylophora lacustris</u>								•	•		•				•	•				1,2,3,6,13,14,18,19,27,45,53		
Family Bougainvilliidae																						
<u>*Garveia franciscana</u>							•	•	•		•				•	•				7,13,14,18,25,27,34,35,45		
Family Rathkeidae																						
<u>Rathkea octopunctata</u>						•				•		•		•	•	•				13,14,27,36		
Order Thecata																						
Family Sertularidae																						
<u>Sertularia stookei</u>																				36 ^a		
Class Scyphozoa																						
Order Semaestomeae																						
Family Pelagidae																						
<u>*Chrysaora quinquecirrha</u>							•	•		•		•		•	•	•				2,3,4,7,13,14,15,36		

LIST OF BENTHIC
MACROINVERTEBRATES
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LIST OF BENTHIC MACROINVERTEBRATES RECORDED FROM THE PATUXENT ESTUARY	Salinity Range					Habitat Type					Feeding Mode		Reproduction					Reference Number				
	Limnetic	Oligohaline	Mesohaline	Polyhaline	Sand	Silt-Clay	Rooted Aquatics	Fouling	Oyster Beds	Intertidal Flats	Filter-Suspension Feeder	Deposit Feeder	Predator	Scavenger	Planktonic Larvae	Brooded Young	Other (e.g., Asexual)		Season of Reproduction			
																			Winter	Spring	Summer	Fall
PHYLUM PLATYHELMINTHES																						
Class Turbellaria																						
Order Polycladida																						
Family Stylochidae																						
* <u>Stylochus ellipticus</u>							•	•	•	•		•	•			•					2,3,5,18,25,39,44,45,46, 54,55	
Family Leptoplanidae																						
<u>Leptoplana ellipsoides</u>												•	•			•					2,3	

LIST OF BENTHIC
MACROINVERTEBRATES
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LIST OF BENTHIC MACROINVERTEBRATES RECORDED FROM THE PATUXENT ESTUARY	Salinity Range					Habitat Type					Feeding Mode			Reproduction					Reference Number			
	Limnetic	Oligohaline	Mesohaline	Polyhaline	Sand	Silt-Clay	Rooted Aquatics	Fouling	Oyster Beds	Intertidal Flats	Filter-Suspension Feeder	Deposit Feeder	Predator	Scavenger	Planktonic Larvae	Brooded Young	Other (e.g., Asexual)	Season of Reproduction				
																		Winter		Spring	Summer	Fall
PHYLUM RHYNCHOCOELA																						
Class Anopla																						
Order Paleonemertea																						
Family Carinomidae																						
<u>Carinoma tremaphoros</u>																					7, 27, 34, 55	
Family Tubulanidae																						
<u>Tubulanus pellucidus</u>																					34, 55	
Order Heteronemertea																						
Family Lineidae																						
<u>Cerebratulus lacteus</u>																					27, 38, 43, 45, 55	
<u>Lineus bicolor</u>																						
* <u>Micrura leidyi</u>																					25, 27, 36, 39, 44, 45, 46, 55	
<u>Micrura rubra</u>																					34	
*Unidentified nemerteans																					this study	

LIST OF BENTHIC
MACROINVERTEBRATES
RECORDED FROM
THE PATUXENT ESTUARY

LIST OF BENTHIC MACROINVERTEBRATES RECORDED FROM THE PATUXENT ESTUARY	Salinity Range					Habitat Type					Feeding Mode					Reproduction					Reference Number	
	Limnetic	Oligohaline	Mesohaline	Polyhaline	Sand	Silt-Clay	Rooted Aquatics	Fouling	Oyster Beds	Intertidal Flats	Filter-Suspension Feeder	Deposit Feeder	Predator	Scavenger	Planktonic Larvae	Brooded Young	Other (e.g., Asexual)	Season of Reproduction				
																		Winter	Spring	Summer		Fall
PHYLUM BRYOZOA																						
Class Gymnolaemata																						
Order Ctenostomata																						
Family Alcyonidiidae																						
<u>Alcyonidium verrilli</u>								•	•		•				•	•				27,36,41,55		
Family Victorellidae																						
<u>Victorella pavida</u>								•	•	•	•				•	•				4,5,6,18,27,38,41,44,45 46,55		
Family Vesicularidae																						
<u>Bowerbankia gracilis</u>								•	•		•				•	•				18,25,27,35,41,55		
Order Cheilostomata																						
Suborder Anasca																						
Family Membraniporidae																						
<u>Membranipora membranacea</u>							•	•		•	•				•	•				18,27,36,55		
<u>Membranipora tenuis</u>							•	•	•	•	•				•	•				18,27,34,41,45,55		
Family Electridae																						
<u>Electra crustulenta</u>							•	•	•		•				•	•				2,3,18,27,35,41,45,55		

LIST OF BENTHIC
MACROINVERTEBRATES
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LIST OF BENTHIC MACROINVERTEBRATES RECORDED FROM THE PATUXENT ESTUARY	Salinity Range					Habitat Type					Feeding Mode		Reproduction					Reference Number				
	Limnetic	Oligohaline	Mesohaline	Polyhaline	Sand	Silt-Clay	Rooted Aquatics	Fouling	Oyster Beds	Intertidal Flats	Filter-Suspension Feeder	Deposit Feeder	Predator	Scavenger	Planktonic Larvae	Brooded Young	Other (e.g., Asexual)		Season of Reproduction			
																			Winter	Spring	Summer	Fall
PHYLUM BRYOZOA (continued)																						
Class Phylactolaemata																						
Order Plumatellina																						
Family Plumatellidae																						
<u>Hyalinella punctata</u>							•		•		•				•	•					3,22,53	
<u>Plumatella repens</u>							•		•		•				•	•					5,53	

LIST OF BENTHIC
MACROINVERTEBRATES
RECORDED FROM
THE PATUXENT ESTUARY

LIST OF BENTHIC MACROINVERTEBRATES RECORDED FROM THE PATUXENT ESTUARY	Salinity Range					Habitat Type					Feeding Mode					Reproduction					Reference Number	
	Limnetic	Oligohaline	Mesohaline	Polyhaline	Sand	Silt-Clay	Rooted Aquatics	Fouling	Oyster Beds	Intertidal Flats	Filter-Suspension Feeder	Deposit Feeder	Predator	Scavenger	Planktonic Larvae	Brooded Young	Other (e.g., Asexual)	Season of Reproduction				
																		Winter	Spring	Summer		Fall
PHYLUM ANNELIDA																						
Class Polychaeta																						
Order Phyllodocida																						
Family Phyllodocidae																						
* <u>Eteone heteropoda</u>				•	•	•	•	•		•				•						18, 27, 34, 36, 39, 42, 44, 46 54, 55		
<u>Eteone lactea</u>				•	•	•	•	•		•				•						27, 34, 39, 42, 55		
Family Goniadidae				•	•				•	•				•						27, 39, 54, 55		
Family Hesionidae																						
* <u>Microphthalmus</u> sp.				•	•		•	•						•						39		
Family Glyceridae																						
<u>Glycera dibranchiata</u>				•	•	•		•	•	•				•						27, 36, 38, 39, 42, 43, 52, 54, 55		
Family Nereidae																						
* <u>Laeonereis culveri</u>				•					•	•					•					5, 6, 7, 21, 25, 27, 39, 42, 45, 54, 55		
* <u>Nereis succinea</u>				•	•			•	•	•	•	•	•	•						1, 2, 3, 4, 6, 7, 18, 25, 27, 28, 34, 36, 38, 42, 44, 45, 46, 55		

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	Limnetic	Oligohaline	Mesohaline	Polyhaline	Sand	Silt-Clay	Rooted Aquatics	Fouling	Oyster Beds	Intertidal Flats	Filter-Suspension Feeder	Deposit Feeder	Predator	Scavenger	Planktonic Larvae	Brooded Young	Other (e.g., Asexual)	Season of Reproduction				
																		Winter	Spring	Summer		Fall
PHYLUM ANNELIDA (continued)																						
Order Capitellida																						
Family Capitellidae																						
* <u>Heteromastus filiformis</u>					•	•	•		•		•			•						22, 27, 28, 35, 39, 44, 45, 46, 47, 52, 54, 55		
<u>Capitella capitata</u>					•	•	•		•		•			•	•					27, 34, 47, 52, 55		
Order Spionida																						
Family Spionidae																						
<u>Paraprionospio pinnata</u>					•	•			•	•	•			•	•					27, 31, 34, 39, 54, 55		
* <u>Polydora ligni</u>					•	•	•	•	•	•		•		•	•					1, 5, 22, 27, 36, 38, 39, 40, 44, 45, 46, 54, 55		
* <u>Polydora sp.</u>						•		•	•	•		•		•	•					7, 22, 26, 27, 28, 34, 39, 44, 46, 52, 54, 55		
* <u>Scolecopides viridis</u>					•	•	•	•	•	•	•			•	•					27, 34, 55		
<u>Spiophanes bombyx</u>					•	•	•			•	•			•	•					22, 39, 54, 55		
* <u>Streblospio benedicti</u>					•	•	•	•	•	•				•	•							

LIST OF BENTHIC MACROINVERTEBRATES RECORDED FROM THE PATUXENT ESTUARY	Salinity Range					Habitat Type					Feeding Mode					Reproduction					Reference Number	
	Limnetic	Oligohaline	Mesohaline	Polyhaline	Sand	Silt-Clay	Rooted Aquatics	Fouling	Oyster Beds	Intertidal Flats	Filter-Suspension Feeder	Deposit Feeder	Predator	Scavenger	Planktonic Larvae	Brooded Young	Other (e.g., Asexual)	Season of Reproduction				
																		Winter	Spring	Summer		Fall
PHYLUM ANNELIDA (continued)																						
Order Terebellida																						
Family Pectinariidae																						
<u>Pectinaria gouldii</u>					•	•	•	•			•			•						1, 5, 27, 31, 36, 38, 39, 43, 54, 55		
Family Ampharetidae																						
<u>*Hypaniola grayi</u>					•	•	•		•		•			•						19, 44, 45, 46, 55		
Class Oligochaeta																						
Order Pleislopora																						
Family Tubificidae																						
<u>Limnodrillus hoffmeisteri</u>		----				•					•				•					2, 3, 7, 19, 22, 44, 45, 46, 3, 4		
<u>Limnodrillus udekemianus</u>						•					•				•							
<u>*Limnodrillus sp. (immature)</u>						•					•				•					this study		
<u>*Tubificodes gabriellae</u>						•					•				•					this study		
<u>*Tubificodes heterochaetus</u>						•					•									this study		
Family Nadidae																						
<u>Chaetogaster diaphanus</u>						•					•	•			•	•				7, 19, 53		

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LIST OF BENTHIC MACROINVERTEBRATES RECORDED FROM THE PATUXENT ESTUARY	Salinity Range					Habitat Type					Feeding Mode					Reproduction					Reference Number	
	Limnetic	Oligohaline	Mesohaline	Polyhaline	Sand	Silt-Clay	Rooted Aquatics	Fouling	Oyster Beds	Intertidal Flats	Filter-Suspension Feeder	Deposit Feeder	Predator	Scavenger	Planktonic Larvae	Brooded Young	Other (e.g., Asexual)	Season of Reproduction				
																		Winter	Spring	Summer		Fall
PHYLUM ANNELIDA (continued)																						
Class Hirudinea																						
Order Rhynchobdellae																						
Family Piscicolidae																						
<u>Trachelobdella vivida</u>					•										•	•				2		
<u>Ichthyobdella</u> sp.					•										•	•				5		
*Unidentified Leeches					•										•	•				this study		
PHYLUM MOLLUSCA																						
Class Gastropoda																						
Subclass Prosobranchia																						
Order Mesogastropoda																						
Family Littorinidae																						
<u>Littoridinops tenuipes</u>										•				•	•					34		
* <u>Littorina</u> sp. (<u>irrorata</u>)																				27, 55		
Family Hydrobiidae																						
<u>Hydrobia salsa</u>														•	•					5, 27		
<u>Hydrobia</u> sp.					•									•	•					4		

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	Limnetic	Oligohaline	Mesohaline	Polyhaline	Sand	Silt-Clay	Rooted Aquatics	Fouling	Oyster Beds	Intertidal Flats	Filter-Suspension Feeder	Deposit Feeder	Predator	Scavenger	Planktonic Larvae	Brooded Young	Other (e.g., Asexual)	Season of Reproduction				
																		Winter	Spring		Summer	Fall
PHYLUM MOLLUSCA																						
Family Epitoniidae																						
Epitonium sp. (rupicolum)					•	•									•	•				27, 39, 55		
Order Neogastropoda																						
Family Nassariidae																						
Nassarius vibex							•				•				•	•				5, 6, 25, 27, 39, 45, 55		
Subclass Opisthobranchia																						
Order Cephalaspidea																						
Family Acteonidae																						
Acteon punctostriatus					•	•			•			•			•					4, 27, 39, 54, 55		
Family Atyidae																						
Haminoea solitaria					•	•						•	•		•					5, 27, 36, 38, 39, 54, 55		
Order Nudibranchia																						
Suborder Doridacea																						
Family Corambidae																						
Corambella baretariae								•				•	•		•					1, 2, 3, 18		
*Doridella obscura					•		•	•				•	•		•					27, 39, 54, 55		

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	Limnetic	Oligohaline	Mesohaline	Polyhaline	Sand	Silt-Clay	Rooted Aquatics	Fouling	Oyster Beds	Intertidal Flats	Filter-Suspension Feeder	Deposit Feeder	Predator	Scavenger	Planktonic Larvae	Brooded Young	Other (e.g., Asexual)	Season of Reproduction				
																		Winter	Spring	Summer		Fall
PHYLUM MOLLUSCA (continued)																						
Subclass Pulmonata																						
Order Basomatophora																						
Family Melampidae																						
<u>Melampus bidentatus</u>							•		•				•		•						1,2,5,18	
Family Amnicolidae																						
<u>Amnicola limosa</u>								•						•							1,2,3	
Class Bivalvia																						
Subclass Pteriomorpha																						
Order Pteronchida																						
Family Mytilidae																						
<u>*Ischadium recurvum</u>					•	•	•	•	•	•				•							4,4,16,17,18,25,27,28, 34,36,38,39,44,45,46, 50,54,55	
<u>Gebensia demissus</u>						•	•	•	•	•				•							1,2,3,4,5,16,17,25,27, 45,55	
<u>Mytilus edulis</u>							•	•	•	•				•							1 ^a ,3 ^a	
Family Ostreidae																						
<u>*Crassostrea virginica</u>					•	•	•	•	•	•				•							1,2,3,16,17,18,27,28,35, 36,38,39,43,44,45,46,54, 55	
Order Heterodontida																						
Family Dreissenidae																						
<u>*Congeria leucopheata</u>						•	•	•		•				•							5,16,17,18,22,25,27,28, 34,36,38,43,44,45,46,55	

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	Limnetic	Oligohaline	Mesohaline	Polyhaline	Sand	Silt-Clay	Rooted Aquatics	Fouling	Oyster Beds	Intertidal Flats	Filter-Suspension Feeder	Deposit Feeder	Predator	Scavenger	Planktonic Larvae	Brooded Young	Other (e.g., Asexual)	Season of Reproduction				
																		Winter	Spring	Summer		Fall
PHYLUM MOLLUSCA (continued)																						
Family Veneridae																						
* <u>Gemma gemma</u>				•					•	•					•					5, 16, 17, 25, 27, 36, 38, 39, 54, 55		
Family Mactridae																						
<u>Mulinia lateralis</u>				•	•	•			•	•				•						16, 17, 25, 27, 34, 36, 38, 39, 43, 50, 54, 55		
* <u>Rangia cuneata</u>				•	•					•				•						4, 5, 16, 17, 25, 27, 28, 34, 39, 43, 44, 45, 46, 54, 55		
Family Tellinidae																						
* <u>Macoma balthica</u>				•	•	•				•	•			•						4, 5, 16, 17, 18, 27, 28, 34, 37, 38, 39, 44, 45, 46, 50, 54, 55		
* <u>Macoma phenax</u>				•	•	•			•	•	•			•						5, 16, 17, 25, 27, 35, 36, 38, 39, 44, 45, 46, 50, 54, 55		
Family Solecurtidae																						
<u>Tagelus plebius</u>				•	•	•			•	•	•			•						2, 3, 16, 17, 27, 29, 30, 36, 38, 39, 43, 55		
Family Solenidae																						
<u>Ensis directus</u>				•	•	•				•				•						16, 17, 27, 38, 45, 54, 55		

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																		Winter	Spring	Summer		Fall
PHYLUM MOLLUSCA (continued)																						
Family Myidae																						
* <u>Mya arenaria</u>	-			•	•	•				•				•			-	-	-	1,2,3,4,5,16,17,25,27, 28,31,34,35,36,38,39, 43,45,54,55		
Family Teredinidae																						
<u>Bankia gouldi</u>	-						•			•				•						3,16,18,27,36,55		

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																			Winter	Spring	Summer	Fall
PHYLUM ARTHROPODA																						
Subphylum Mandibulata																						
Class Crustacea																						
Subclass Cirripedia																						
Order Thoracica																						
Suborder Balanomorpha																						
Family Balanidae																						
<u>Balanus eburneus</u>																				1,2,3,4,5,6,10,27,36, 38,49,51,55		
* <u>Balanus improvisus</u>																				4,5,6,7,10,18,27,34,49, 51,54,55		
Subclass Malacostraca																						
Superorder Peracarida																						
Order Tanaidacea																						
Family Paratanaidae																						
<u>Leptochelia rapax</u>																				5,18,27,45,54		

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																			Winter	Spring	Summer	Fall
PHYLUM ARTHROPODA (continued)																						
Order Isopoda																						
Suborder Anthuridea																						
Family Anthuridae																						
<u>Cyathura polita</u>					•	•	•	•				•	•		•						1, 2, 3, 4, 5, 6, 7, 11, 12, 22, 27, 28, 31, 34, 36, 38, 39, 44, 45, 46, 54, 55	
Suborder Valvifera																						
Family Idoteidae																						
* <u>Chiridotea almyra</u>					•	•	•	•				•	•		•						22, 27, 28, 34, 44, 45, 46, 55	
* <u>Edotea triloba</u>					•	•	•	•	•			•	•		•						7, 27, 28, 34, 39, 44, 45, 46, 54, 55	
Suborder Flabellifera																						
Family Cymothoidae																						
<u>Lironeca ovalis</u>																					7, 27	
Family Sphaeromidae																						
<u>Cassidinisca lunifrons</u>									•	•		•	•		•						2, 25, 27, 28, 44, 45, 46, 55	

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																		Winter	Spring	Summer		Fall
PHYLUM ARTHROPODA (continued)																						
Suborder Onoscoidea																						
Family Oniscidae																						
<u>Philoscia vittata</u>																				4,27		
<u>Tracheoniscus rathkei</u>																				1 ^a ,2 ^a ,3 ^a		
Order Amphipoda																						
Suborder Gammaridea																						
Family Amphithoidae																						
<u>Cymadusa compta</u>																				5,6,7,9,18,24,25,27,55		
Family Corophiidae																						
* <u>Corophium lacustre</u>																				1,2,3,4,5,6,7,9,18,19, 24,25,27,28,34,39,44,45, 46,54,55		
Family Gammaridae																						
<u>Gammarus daiberi</u>																				5,8,9,27,32,45,55		
<u>Gammarus fasciatus</u>																				1,2,3,4,18,19,34,45,53		
<u>Gammarus mucronatus</u>																				1,2,3,4,5,6,8,9,18,27, 32,39,45,54,55		

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																		Winter	Spring		Summer	Fall
PHYLUM ARTHROPODA (continued)																						
<u>Gammarus palustris</u>				•	•	•	•	•			•		•		•					6, 8, 9, 19, 24, 27, 34, 45, 55		
<u>Gammarus tigrinus</u>				•	•	•	•	•			•		•		•					6, 8, 9, 24, 27, 45, 55		
* <u>Melita nitida</u>				•		•	•	•			•		•		•					1, 2, 3, 4, 5, 6, 8, 18, 24, 27, 28, 34, 39, 44, 45, 46, 54, 55		
Family Haustoriidae																						
<u>Lepidactylus dytiscus</u>				•					•	•			•		•					7, 23, 27, 28, 32, 45, 55		
Family Oedicerotidae																						
* <u>Monoculodes edwardsi</u>				•	•	•					•		•		•					9, 19, 24, 27, 28, 34, 39, 45, 54, 55		
Family Photidae																						
* <u>Leptocheirus plumulosus</u>				•	•	•				•	•				•					7, 9, 24, 27, 28, 34, 39, 44, 45, 46, 54, 55		
Family Talitridae																						
<u>Orchestia grillus</u>									•		•		•		•					1, 2, 3, 4, 5, 9, 27		
<u>Talorchestia longicornis</u>									•		•		•		•					1, 2, 3, 4, 5, 9, 19, 27, 55		
Order Mysidacea																						
Family Mysidae																						
* <u>Neomysis americana</u>				•	•	•	•	•	•	•	•	•	•	•	•					27, 36, 39, 45, 54, 55		

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																		Winter	Spring	Summer		Fall
PHYLUM ARTHROPODA (continued)																						
Order Decapoda																						
Intraorder Caridea																						
Family Palaemonidae																						
<u>Palaemonetes intermedius</u>				•	•	•	•	•			•	•	•	•						1, 2, 5, 27, 55		
<u>Palaemonetes pugio</u>				•	•	•	•	•			•	•	•	•						4, 5, 6, 7, 27, 55		
<u>Palaemonetes vulgaris</u>																				7 ^a , 18 ^a , 36 ^a , 38 ^a		
Family Crangonidae																						
<u>Crangon septemspinosa</u>				•	•	•		•			•	•								25, 27, 39, 45, 54, 55		
Interorder Brachyura																						
Section Brachyryhyncha																						
Family Portunidae																						
* <u>Callinectes sapidus</u>				•	•	•	•	•			•	•	•	•						1, 2, 3, 6, 7, 27, 35, 36, 38, 45, 55		
Family Xanthidae																						
<u>Eurypanopeus depressus</u>								•			•	•	•	•						25, 27, 35, 36, 38, 45, 48, 55		
<u>Neopanope texana sayi</u>								•			•	•	•	•						5, 27, 55		
* <u>Rhithropanopeus harrisii</u>								•			•	•	•	•						1, 2, 3, 4, 6, 7, 18, 19, 27, 28, 34, 35, 38, 39, 44, 45, 46, 48, 55		

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																			Winter	Spring	Summer	Fall
PHYLUM CHORDATA																						
Subphylum Urochordata																						
Class Ascidiacea																						
Order Pleurogona																						
Suborder Stolidobranchiata																						
Family Molgulidae																						
<u>Molgula manhattensis</u>																					1, 2, 3, 4, 5, 6, 18, 27, 34, 35, 36, 38, 39, 45, 54, 55	

References for appendix A

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APPENDIX B

DATA SUMMARIES

CHALK POINT BENTHIC STUDIES
STATION 3

0.5 MM SCREEN

JULY 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
MACOMA BALTHICA	90	900.0	94.34	32.6	32.6	100.0
LEPTOCHEIRUS PLUMULOSUS	72	720.0	134.16	26.1	58.7	100.0
CYATHURA POLITA	32	320.0	70.71	11.6	70.3	100.0
HETEROMASTUS FILIFORMIS	29	290.0	57.23	10.5	80.8	100.0
MELITA NITIDA	19	190.0	29.58	6.9	87.7	100.0
OLIGOCHAETE A	16	160.0	58.31	5.8	93.5	75.0
MACOMA PHENAX	7	70.0	25.98	2.5	96.0	100.0
UNIDENTIFIED NEMERTEAN	6	60.0	10.00	2.2	98.2	100.0
NEREIS SUCCINEA	2	20.0	10.00	.7	98.9	50.0
RANGIA CUNEATA	1	10.0	8.66	.4	99.3	25.0
OLIGOCHAETE B	1	10.0	8.66	.4	99.6	25.0
SCOLECOLEPIDES VIRIDIS	1	10.0	8.66	.4	100.0	25.0
TOTALS	276	2760.0	50.99			

CHALK POINT BENTHIC STUDIES
STATION 5

0.5 MM SCREEN

JULY 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
MACOMA BALTHICA	111	1110.0	144.48	38.3	38.3	100.0
OLIGOCHAETE A	59	590.0	305.41	20.3	58.6	100.0
HETEROMASTUS FILIFORMIS	59	590.0	101.37	20.3	79.0	100.0
LEPTOCHEIRUS PLUMULOSUS	14	140.0	10.00	4.8	83.8	100.0
OLIGOCHAETE B	11	110.0	32.79	3.8	87.6	75.0
NEREIS SUCCINEA	11	110.0	47.70	3.8	91.4	75.0
SCOLECOLEPIDES VIRIDIS	10	100.0	43.59	3.4	94.8	75.0
UNIDENTIFIED NEMERTEAN	5	50.0	8.66	1.7	96.6	100.0
NEOMYSIS AMERICANA	4	40.0	24.49	1.4	97.9	50.0
CYATHURA POLITA	4	40.0	14.14	1.4	99.3	75.0
RANGIA CUNEATA	1	10.0	8.66	.3	99.7	25.0
MACOMA PHENAX	1	10.0	8.66	.3	100.0	25.0
TOTALS	290	2900.0	397.37			

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CHALK POINT BENTHIC STUDIES
STATION 41

0.5 MM SCREEN

JULY 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
MACOMA BALTHICA	60	600.0	101.98	34.7	34.7	100.0
LEPTOCHEIRUS PLUMULOSUS	28	280.0	14.14	16.2	50.9	100.0
OLIGOCHAETE A	26	260.0	70.00	15.0	65.9	100.0
HETEROMASTUS FILIFORMIS	16	160.0	42.43	9.2	75.1	100.0
SCOLECOLEPIDES VIRIDIS	13	130.0	47.70	7.5	82.7	75.0
CYATHURA POLITA	11	110.0	25.98	6.4	89.0	100.0
RANGIA CUNEATA	11	110.0	35.71	6.4	95.4	100.0
OLIGOCHAETE B	3	30.0	16.58	1.7	97.1	50.0
NEOMYSIS AMERICANA	2	20.0	10.00	1.2	98.3	50.0
COROPHIUM SP.	1	10.0	8.66	.6	98.8	25.0
MACOMA PHENAX	1	10.0	8.66	.6	99.4	25.0
UNIDENTIFIED NEMERTEAN	1	10.0	8.66	.6	100.0	25.0
TOTALS	173	1730.0	263.20			

CHALK POINT BENTHIC STUDIES
STATION 8

0.5 MM SCREEN

JULY 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
OLIGOCHAETE A	429	4290.0	1144.24	52.4	52.4	100.0
OLIGOCHAETE 9	165	1650.0	484.23	20.2	72.6	100.0
LEPTOCHEIRUS PLUMULOSUS	88	880.0	101.98	10.8	83.4	100.0
MACOMA BALTHICA	50	500.0	51.96	6.1	89.5	100.0
CYATHURA POLITA	28	280.0	24.49	3.4	92.9	100.0
SCOLECOLEPIDES VIRIDIS	22	220.0	51.96	2.7	95.6	100.0
TENDIPEDIDAE	12	120.0	28.28	1.5	97.1	100.0
HETEROMASTUS FILIFORMIS	8	80.0	24.49	1.0	98.0	100.0
RANGIA CUNEATA	7	70.0	16.58	.9	98.9	100.0
UNIDENTIFIED NEMERTEAN	5	50.0	21.79	.6	99.5	75.0
MACOMA PHENAX	3	30.0	16.58	.4	99.9	50.0
EDOTEA TRILOBA	1	10.0	8.66	.1	100.0	25.0
TOTALS	818	8180.0	1619.41			

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CHALK POINT BENTHIC STUDIES
STATION 9

0.5 MM SCREEN

JULY 1979

TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
OLIGOCHAETE A	372	3720.0	670.07	73.8	73.8	100.0
LEPTOCHEIRUS PLUMULOSUS	49	490.0	99.37	9.7	83.5	100.0
OLIGOCHAETE 3	36	360.0	70.71	7.1	90.7	100.0
SCOLECOLEPIDES VIRIDIS	19	190.0	62.25	3.8	94.4	100.0
CYATHURA POLITA	12	120.0	24.49	2.4	96.8	100.0
MACOMA BALTHICA	5	50.0	25.98	1.0	97.8	50.0
TENDIPEIDAE	4	40.0	14.14	.8	98.6	75.0
MELITA NITIDA	2	20.0	10.00	.4	99.0	50.0
NEOMYSIS AMERICANA	1	10.0	8.66	.2	99.2	25.0
GAMMARUS SP.	1	10.0	8.66	.2	99.4	25.0
RANGIA CUNEATA	1	10.0	8.66	.2	99.6	25.0
MACOMA PHENAX	1	10.0	8.66	.2	99.8	25.0
HETEROMASTUS FILIFORMIS	1	10.0	8.66	.2	100.0	25.0
TOTALS	504	5040.0	715.96			

CHALK POINT BENTHIC STUDIES
STATION 10

0.5 MM SCREEN

JULY 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
LEPTOCHEIRUS PLUMULOSUS	43	430.0	69.82	38.7	38.7	100.0
OLIGOCHAETE A	32	320.0	117.47	28.8	67.6	100.0
SCOLECOLEPIDES VIRIDIS	8	80.0	37.42	7.2	74.8	75.0
CYATHURA POLITA	6	60.0	30.00	5.4	80.2	75.0
TENDIPEDIDAE	5	50.0	21.79	4.5	84.7	75.0
RANGIA CUNEATA	5	50.0	16.58	4.5	89.2	75.0
UNIDENTIFIED NEMERTEAN	4	40.0	14.14	3.6	92.8	75.0
MACOMA PHENAX	2	20.0	10.00	1.8	94.6	50.0
CHIRIDOTEA ALMYRA	1	10.0	8.66	.9	95.5	25.0
NEOMYSIS AMERICANA	1	10.0	8.66	.9	96.4	25.0
GAMMARUS SP.	1	10.0	8.66	.9	97.3	25.0
EDOTEA TRILOBA	1	10.0	8.66	.9	98.2	25.0
COROPHIUM SP.	1	10.0	8.66	.9	99.1	25.0
OLIGOCHAETE B	1	10.0	8.66	.9	100.0	25.0
TOTALS	111	1110.0	166.36			

CHALK POINT BENTHIC STUDIES
STATION 1

0.5 MM SCREEN

SEPTEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
HETEROMASTUS FILIFORMIS	148	1973.3	71.39	38.3	38.3	100.0
STREBLOSPID BENEDICTI	73	973.3	245.37	18.9	57.3	100.0
MACOMA PHENAX	59	786.7	94.91	15.3	72.5	100.0
OLIGOCHAETE A	32	426.7	60.61	8.3	80.8	100.0
SCOLECOLEPIDES VIRIDIS	21	280.0	49.89	5.4	86.3	100.0
NEREIS SUCCINEA	16	213.3	71.39	4.1	90.4	100.0
CYATHURA POLITA	14	186.7	10.89	3.6	94.0	100.0
UNIDENTIFIED NEMERTEAN	9	120.0	49.89	2.3	96.4	100.0
MACOMA BALTHICA	6	80.0	32.66	1.6	97.9	66.7
ETEONE HETEROPODA	2	26.7	10.89	.5	98.4	66.7
TENDIPEDIDAE	1	13.3	10.89	.3	98.7	33.3
NEOMYSIS AMERICANA	1	13.3	10.89	.3	99.0	33.3
EDOTEA TRILOBA	1	13.3	10.89	.3	99.2	33.3
MULINIA LATERALIS	1	13.3	10.89	.3	99.5	33.3
HYPANIOLA GRAYI	1	13.3	10.89	.3	99.7	33.3
LAONEREIS CULVERI	1	13.3	10.89	.3	100.0	33.3
TOTALS	386	5146.7	339.59			

CHALK POINT BENTHIC STUDIES
STATION 2

0.5 MM SCREEN

SEPTEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
SCOLECOLEPIDES VIRIDIS	27	360.0	56.57	27.8	27.8	100.0
STREBLOSPIO BENEDICTI	25	333.3	93.02	25.8	53.6	100.0
HETEROMASTUS FILIFORMIS	24	320.0	67.99	24.7	78.4	100.0
MACOMA PHENAX	9	120.0	32.66	9.3	87.6	100.0
NEREIS SUCCINEA	3	40.0	18.86	3.1	90.7	66.7
UNIDENTIFIED NEMERTEAN	3	40.0	32.66	3.1	93.8	33.3
MACOMA BALTHICA	2	26.7	21.77	2.1	95.9	33.3
LAEONEREIS CULVERI	2	26.7	21.77	2.1	97.9	33.3
LEPTOCHEIRUS PLUMULOSUS	1	13.3	10.89	1.0	99.0	33.3
OLIGOCHAETE A	1	13.3	10.89	1.0	100.0	33.3
TOTALS	97	1293.3	216.91			

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CHALK POINT BENTHIC STUDIES
STATION 3

0.5 MM SCREEN

SEPTEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
OLIGOCHAETE A	81	1080.0	296.35	34.2	34.2	100.0
MACOMA BALTHICA	58	773.3	125.55	24.5	58.6	100.0
HETEROMASTUS FILIFORMIS	25	333.3	115.21	10.5	69.2	100.0
MACOMA PHENAX	16	213.3	43.55	6.8	75.9	100.0
NEREIS SUCCINEA	11	146.7	60.61	4.6	80.6	66.7
CYATHURA POLITA	10	133.3	21.77	4.2	84.8	100.0
LEPTOCHEIRUS PLUMULOSUS	9	120.0	97.98	3.8	88.6	33.3
STREBLOSPIO BENEDICTI	7	93.3	21.77	3.0	91.6	100.0
POLYDORA SP.	6	80.0	65.32	2.5	94.1	33.3
OLIGOCHAETE B	5	66.7	10.89	2.1	96.2	100.0
SCOLECOLEPIDES VIRIDIS	5	66.7	28.80	2.1	98.3	66.7
EDOTEA TRILOBA	2	26.7	21.77	.8	99.2	33.3
MELITA NITIDA	1	13.3	10.89	.4	99.6	33.3
UNIDENTIFIED NEMERTEAN	1	13.3	10.89	.4	100.0	33.3
TOTALS	237	3160.0	525.61			

CHALK POINT BENTHIC STUDIES
STATION 4

0.5 MM SCREEN

SEPTEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
HETEROMASTUS FILIFORMIS	99	1320.0	277.77	37.5	37.5	100.0
CYATHURA POLITA	37	493.3	223.37	14.0	51.5	100.0
MACOMA PHENAX	34	453.3	158.14	12.9	64.4	100.0
OLIGOCHAETE A	21	280.0	131.99	8.0	72.3	100.0
MACOMA BALTHICA	20	266.7	89.11	7.6	79.9	100.0
UNIDENTIFIED NEMERTEAN	12	160.0	.00	4.5	84.5	100.0
SCOLECOLEPIDES VIRIDIS	10	133.3	47.45	3.8	88.3	100.0
RANGIA CUNEATA	9	120.0	49.89	3.4	91.7	66.7
STREBLOSPIO BENEDICTI	9	120.0	32.66	3.4	95.1	100.0
NEREIS SUCCINEA	9	120.0	56.57	3.4	98.5	66.7
LEPTOCHEIRUS PLUMULOSUS	1	13.3	10.89	.4	98.9	33.3
EDOTEA TRILOBA	1	13.3	10.89	.4	99.2	33.3
OLIGOCHAETE B	1	13.3	10.89	.4	99.6	33.3
POLYDORA SP.	1	13.3	10.89	.4	100.0	33.3
TOTALS	264	3520.0	562.22			

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CHALK POINT BENTHIC STUDIES
STATION 5

0.5 MM SCREEN

SEPTEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
MACOMA BALTHICA	154	1540.0	155.88	63.6	63.6	100.0
OLIGOCHAETE A	36	360.0	92.74	14.9	79.5	100.0
OLIGOCHAETE B	26	260.0	85.44	10.7	89.3	100.0
HETEROMASTUS FILIFORMIS	16	160.0	28.28	6.6	95.9	100.0
CYATHURA POLITA	3	30.0	8.66	1.2	97.1	75.0
MACOMA PHENAX	2	20.0	10.00	.8	97.9	50.0
NEREIS SUCCINEA	2	20.0	10.00	.8	98.8	50.0
UNIDENTIFIED NEMERTEAN	2	20.0	10.00	.8	99.6	50.0
SCOLECOLEPIDES VIRIDIS	1	10.0	8.66	.4	100.0	25.0
TOTALS	242	2420.0	83.07			

CHALK POINT BENTHIC STUDIES
STATION 42

0.5 MM SCREEN

SEPTEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
MACOMA BALTHICA	291	2328.0		85.3	85.3	100.0
OLIGOCHAETE A	41	328.0		12.0	97.4	100.0
HETEROMASTUS FILIFORMIS	4	32.0		1.2	98.5	100.0
OLIGOCHAETE B	2	16.0		.6	99.1	100.0
SCOLECOLEPIDES VIRIDIS	2	16.0		.6	99.7	100.0
NEREIS SUCCINEA	1	8.0		.3	100.0	100.0
TOTALS	341	2728.0				

CHALK POINT BENTHIC STUDIES
STATION 6

0.5 MM SCREEN

SEPTEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
CYATHURA POLITA	22	293.3	47.45	23.4	23.4	100.0
MACOMA BALTHICA	17	253.3	76.21	20.2	43.6	100.0
LEPTOCHEIRUS PLUMULOSUS	17	226.7	60.61	18.1	61.7	100.0
OLIGOCHAETE A	11	146.7	39.25	11.7	73.4	100.0
UNIDENTIFIED NEMERTEAN	7	93.3	10.89	7.4	80.9	100.0
MACOMA PHENAX	6	80.0	18.86	6.4	87.2	100.0
HETEROMASTUS FILIFORMIS	6	80.0	49.89	6.4	93.6	66.7
RANGIA CUNEATA	2	26.7	10.89	2.1	95.7	66.7
OLIGOCHAETE B	2	26.7	10.89	2.1	97.9	66.7
MELITA NITIDA	1	13.3	10.89	1.1	98.9	33.3
SCOLECOLEPIDES VIRIDIS	1	13.3	10.89	1.1	100.0	33.3
TOTALS	94	1253.3	107.22			

CHALK POINT BENTHIC STUDIES
STATION 41

0.5 MM SCREEN

SEPTEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
OLIGOCHAETE A	74	740.0	108.17	56.9	56.9	100.0
MACOMA BALTHICA	20	200.0	37.42	15.4	72.3	100.0
OLIGOCHAETE 3	9	90.0	32.79	6.9	79.2	100.0
UNIDENTIFIED NEMERTEAN	7	70.0	29.58	5.4	84.6	75.0
METEROMASTUS FILIFORMIS	6	60.0	22.36	4.6	89.2	75.0
CYATHURA POLITA	5	50.0	16.58	3.8	93.1	75.0
MACOMA PHENAX	3	30.0	8.66	2.3	95.4	75.0
TENDIPEDIDAE	2	20.0	17.32	1.5	96.9	25.0
LEPTOCHEIRUS PLUMULOSUS	2	20.0	10.00	1.5	98.5	50.0
COROPHIUM SP.	1	10.0	8.66	.8	99.2	25.0
RANGIA CUNEATA	1	10.0	8.66	.8	100.0	25.0
TOTALS	130	1300.0	131.53			

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CHALK POINT BENTHIC STUDIES
STATION 25

0.5 MM SCREEN

SEPTEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
MACOMA BALTHICA	106	848.0		47.3	47.3	100.0
OLIGOCHAETE A	84	672.0		37.5	84.8	100.0
OLIGOCHAETE B	14	112.0		6.3	91.1	100.0
LEPTOCHERUS PLUMULOSUS	7	56.0		3.1	94.2	100.0
CYATHURA POLITA	6	48.0		2.7	96.9	100.0
MACOMA PHENAX	3	24.0		1.3	98.2	100.0
UNIDENTIFIED NEMERTEAN	1	8.0		.4	98.7	100.0
RANGIA CUNEATA	1	8.0		.4	99.1	100.0
HETEROMASTUS FILIFORMIS	1	8.0		.4	99.6	100.0
SCOLECOLEPIDES VIRIDIS	1	8.0		.4	100.0	100.0
TOTALS	242	1936.0				

CHALK POINT BENTHIC STUDIES
STATION 25

0.5 MM SCREEN

SEPTEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
MACOMA BALTHICA	106	848.0		47.3	47.3	100.0
OLIGOCHAETE A	84	672.0		37.5	84.8	100.0
OLIGOCHAETE B	14	112.0		6.3	91.1	100.0
LEPTOCHERUS PLUMULOSUS	7	56.0		3.1	94.2	100.0
CYATHURA POLITA	6	48.0		2.7	96.9	100.0
MACOMA PHENAX	3	24.0		1.3	98.2	100.0
UNIDENTIFIED NEMERTEAN	1	8.0		.4	98.7	100.0
RANGIA CUNEATA	1	8.0		.4	99.1	100.0
HETEROMASTUS FILIFORMIS	1	8.0		.4	99.6	100.0
SCOLECOLEPIDES VIRIDIS	1	8.0		.4	100.0	100.0
TOTALS	242	1936.0				

CHALK POINT BENTHIC STUDIES
STATION 43

0.5 MM SCREEN

SEPTEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
OLIGOCHAETE A	259	2072.0		60.5	60.5	100.0
MACOMA BALTHICA	110	880.0		25.7	86.2	100.0
OLIGOCHAETE B	56	448.0		13.1	99.3	100.0
MACOMA PHENAX	1	8.0		.2	99.5	100.0
TENDIPEDIDAE	1	8.0		.2	99.8	100.0
CHAOBORUS SP.	1	8.0		.2	100.0	100.0
TOTALS	428	3424.0				

CHALK POINT BENTHIC STUDIES
STATION 43

0.5 MM SCREEN

SEPTEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
OLIGOCHAETE A	259	2072.0		60.5	60.5	100.0
MACOMA BALTHICA	110	880.0		25.7	86.2	100.0
OLIGOCHAETE B	56	448.0		13.1	99.3	100.0
MACOMA PHENAX	1	8.0		.2	99.5	100.0
TENDIPEDIDAE	1	8.0		.2	99.8	100.0
CHAOBORUS SP.	1	8.0		.2	100.0	100.0
TOTALS	428	3424.0				

CHALK POINT BENTHIC STUDIES
STATION 8

0.5 MM SCREEN

SEPTEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
OLIGOCHAETE A	505	5050.0	672.96	80.3	80.3	100.0
OLIGOCHAETE B	62	620.0	190.00	9.9	90.1	100.0
MACOMA BALTHICA	35	350.0	80.47	5.6	95.7	100.0
LEPTOCHEIRUS PLUMULOSUS	10	100.0	33.17	1.6	97.3	100.0
CYATHURA POLITA	8	80.0	14.14	1.3	98.6	100.0
TENDIPEDIDAE	2	20.0	17.32	.3	98.9	25.0
RANGIA CUNEATA	2	20.0	10.00	.3	99.2	50.0
SCOLECOLEPIDES VIRIDIS	2	20.0	17.32	.3	99.5	25.0
MACOMA PHENAX	1	10.0	8.66	.2	99.7	25.0
HETEROMASTUS FILIFORMIS	1	10.0	8.66	.2	99.8	25.0
UNIDENTIFIED NEMERTEAN	1	10.0	8.66	.2	100.0	25.0
TOTALS	629	6290.0	914.81			

CHALK POINT BENTHIC STUDIES
STATION 9

0.5 MM SCREEN

SEPTEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
OLIGOCHAETE A	94	940.0	185.74	77.7	77.7	100.0
MACOMA BALTHICA	6	60.0	30.00	5.0	82.6	50.0
LEPTOCHEIRUS PLUMULOSUS	4	40.0	34.64	3.3	86.0	25.0
OLIGOCHAETE B	4	40.0	24.49	3.3	89.3	50.0
TENDIPEDIDAE	3	30.0	16.58	2.5	91.7	50.0
CYATHURA POLITA	3	30.0	8.66	2.5	94.2	75.0
SCOLECOLEPIDES VIRIDIS	3	30.0	16.58	2.5	96.7	50.0
UNIDENTIFIED NEMERTEAN	2	20.0	10.00	1.7	98.3	50.0
NEOMYSIS AMERICANA	1	10.0	8.66	.8	99.2	25.0
RANGIA CUNEATA	1	10.0	8.66	.8	100.0	25.0
TOTALS	121	1210.0	224.67			

CHALK POINT BENTHIC STUDIES
STATION 27

0.5 MM SCREEN

SEPTEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
OLIGOCHAETE A	52	693.3	125.55	69.3	69.3	100.0
OLIGOCHAETE B	11	146.7	47.45	14.7	84.0	100.0
LEPTOCHEIRUS PLUMULOSUS	5	66.7	21.77	6.7	90.7	100.0
MACOMA BALTHICA	5	66.7	21.77	6.7	97.3	100.0
TENDIPEDIDAE	1	13.3	10.89	1.3	98.7	33.3
RANGIA CUNEATA	1	13.3	10.89	1.3	100.0	33.3
TOTALS	75	1000.0	199.56			

CHALK POINT BENTHIC STUDIES
STATION 28

0.5 MM SCREEN

SEPTEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
OLIGOCHAETE A	92	1226.7	374.44	79.3	79.3	100.0
OLIGOCHAETE B	9	120.0	65.32	7.8	87.1	100.0
MACOMA BALTHICA	6	80.0	18.86	5.2	92.2	100.0
RANGIA CUNEATA	3	40.0	.00	2.6	94.8	100.0
TENDIPEDIDAE	2	26.7	21.77	1.7	96.6	33.3
CYATHURA POLITA	2	26.7	21.77	1.7	98.3	33.3
MELITA NITIDA	1	13.3	10.89	.9	99.1	33.3
SCOLECOLEPIDES VIRIDIS	1	13.3	10.89	.9	100.0	33.3
TOTALS	116	1546.7	427.64			

CHALK POINT BENTHIC STUDIES
STATION 10

0.5 MM SCREEN

SEPTEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
SCOLECOLEPIDES VIRIDIS	16	160.0	104.88	26.7	26.7	75.0
CYATHURA POLITA	15	150.0	38.41	25.0	51.7	100.0
POLYDORA SP.	9	90.0	77.94	15.0	66.7	25.0
TENDIPEDIDAE	6	60.0	17.32	10.0	76.7	75.0
COROPHIUM SP.	6	60.0	30.00	10.0	86.7	75.0
LEPTOCHEIRUS PLUMULOSUS	3	30.0	8.66	5.0	91.7	75.0
OLIGOCHAETE A	2	20.0	10.00	3.3	95.0	50.0
CHAOBORUS SP.	1	10.0	8.66	1.7	96.7	25.0
STREBLOSPIO BENEDICTI	1	10.0	8.66	1.7	98.3	25.0
METEROMASTUS FILIFORMIS	1	10.0	8.66	1.7	100.0	25.0
TOTALS	60	600.0	231.08			

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CHALK POINT BENTHIC STUDIES
STATION 11

0.5 MM SCREEN

SEPTEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
TENDIPEDIDAE	2	26.7	10.89	25.0	25.0	66.7
CHAOBORUS SP.	1	13.3	10.89	12.5	37.5	33.3
GAMMARUS SP.	1	13.3	10.89	12.5	50.0	33.3
COROPHIUM SP.	1	13.3	10.89	12.5	62.5	33.3
OLIGOCHAETE B	1	13.3	10.89	12.5	75.0	33.3
OLIGOCHAETE A	1	13.3	10.89	12.5	87.5	33.3
HETEROMASTUS FILIFORMIS	1	13.3	10.89	12.5	100.0	33.3
TOTALS	8	106.7	28.80			

CHALK POINT BENTHIC STUDIES
STATION 12

0.5 MM SCREEN

SEPTEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
OLIGOCHAETE B	51	680.0	161.11	85.0	85.0	100.0
TENDIPEDIDAE	7	93.3	28.80	11.7	96.7	100.0
CHIRIDOTEA ALMYRA	1	13.3	10.89	1.7	98.3	33.3
COROPHIUM SR.	1	13.3	10.89	1.7	100.0	33.3
TOTALS	60	800.0	172.82			

CHALK POINT BENTHIC STUDIES
STATION 22

0.5 MM SCREEN

SEPTEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
OLIGOCHAETE B	190	2533.3	158.14	93.1	93.1	100.0
NEMATOMORPHA	6	80.0	18.86	2.9	96.1	100.0
COROPHIUM SP.	3	40.0	18.86	1.5	97.5	66.7
TENDIPEDIDAE	2	26.7	21.77	1.0	98.5	33.3
MELITA NITIDA	1	13.3	10.89	.5	99.0	33.3
GAMMARUS SP.	1	13.3	10.89	.5	99.5	33.3
LAONEREIS CULVERI	1	13.3	10.89	.5	100.0	33.3
TOTALS	204	2720.0	130.64			

CHALK POINT BENTHIC STUDIES
STATION 3

0.5 MM SCREEN

NOVEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
MACOMA BALTHICA	118	1180.0	206.16	34.6	34.6	100.0
LEPTOCHEIRUS PLUMULOSUS	64	640.0	153.62	18.8	53.4	100.0
HETEROMASTUS FILIFORMIS	64	640.0	106.77	18.8	72.1	100.0
OLIGOCHAETE A	51	510.0	73.99	15.0	87.1	100.0
MACOMA PHENAX	19	190.0	38.41	5.6	92.7	100.0
CYATHURA POLITA	11	110.0	21.79	3.2	95.9	100.0
OLIGOCHAETE B	6	60.0	22.36	1.8	97.7	75.0
UNIDENTIFIED NEMERTEAN	3	30.0	8.66	.9	98.5	75.0
MELITA NITIDA	1	10.0	8.66	.3	98.8	25.0
EDOTEA TRILOBA	1	10.0	8.66	.3	99.1	25.0
RANGIA CUNEATA	1	10.0	8.66	.3	99.4	25.0
SCOLECOLEPIDES VIRIDIS	1	10.0	8.66	.3	99.7	25.0
NEREIS SUCCINEA	1	10.0	8.66	.3	100.0	25.0
TOTALS	341	3410.0	300.46			

CHALK POINT BENTHIC STUDIES
STATION 5

0.5 MM SCREEN

NOVEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
OLIGOCHAETE A	339	3390.0	636.93	66.7	66.7	100.0
MACOMA BALTHICA	117	1170.0	99.37	23.0	89.8	100.0
OLIGOCHAETE B	39	390.0	111.69	7.7	97.4	100.0
NEREIS SUCCINEA	5	50.0	21.79	1.0	98.4	75.0
UNIDENTIFIED NEMERTEAN	3	30.0	16.58	.6	99.0	50.0
LEPTOCHEIRUS PLUMULOSUS	2	20.0	17.32	.4	99.4	25.0
HETEROMASTUS FILIFORMIS	2	20.0	10.00	.4	99.8	50.0
COROPHIUM SP.	1	10.0	8.66	.2	100.0	25.0
TOTALS	508	5080.0	799.62			

CHALK POINT BENTHIC STUDIES
STATION 41

0.5 MM SCREEN

NOVEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
OLIGOCHAETE A	384	3840.0	1356.83	77.4	77.4	100.0
MACOMA BALTHICA	47	470.0	69.82	9.5	86.9	100.0
OLIGOCHAETE B	28	280.0	96.95	5.6	92.5	100.0
HETEROMASTUS FILIFORMIS	11	110.0	29.58	2.2	94.8	100.0
LEPTOCHEIRUS PLUMULOSUS	9	90.0	32.79	1.8	96.6	100.0
TENDIPEDIDAE	3	30.0	16.58	.6	97.2	50.0
GAMMARUS SP.	3	30.0	16.58	.6	97.8	50.0
CYATHURA POLITA	2	20.0	10.00	.4	98.2	50.0
COROPHIUM SP.	2	20.0	10.00	.4	98.6	50.0
SCOLECOLEPIDES VIRIDIS	2	20.0	10.00	.4	99.0	50.0
UNIDENTIFIED NEMERTEAN	2	20.0	10.00	.4	99.4	50.0
EDOTEA TRILOBA	1	10.0	8.66	.2	99.6	25.0
RANGIA CUNEATA	1	10.0	8.66	.2	99.8	25.0
MACOMA PHENAX	1	10.0	8.66	.2	100.0	25.0
TOTALS	496	4960.0	1407.34			

CHALK POINT BENTHIC STUDIES
STATION 8

0.5 MM SCREEN

NOVEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
OLIGOCHAETE A	1513	15130.0	4720.62	93.4	93.4	100.0
OLIGOCHAETE 3	57	570.0	128.35	3.5	96.9	100.0
MACOMA BALTHICA	35	350.0	51.72	2.2	99.1	100.0
CYATHURA POLITA	5	50.0	16.58	.3	99.4	75.0
EDOTEA TRILOBA	2	20.0	17.32	.1	99.5	25.0
MACOMA PHENAX	2	20.0	10.00	.1	99.6	50.0
SCOLECOLEPIDES VIRIDIS	2	20.0	10.00	.1	99.8	50.0
HETEROMASTUS FILIFORMIS	2	20.0	10.00	.1	99.9	50.0
GAMMARUS SP.	1	10.0	8.66	.1	99.9	25.0
UNIDENTIFIED NEMERTEAN	1	10.0	8.66	.1	100.0	25.0
TOTALS	1620	16200.0	4841.24			

CHALK POINT BENTHIC STUDIES
STATION 9

0.5 MM SCREEN

NOVEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
OLIGOCHAETE A	245	2450.0	467.84	88.4	88.4	100.0
OLIGOCHAETE B	10	100.0	75.50	3.6	92.1	50.0
MACOMA BALTHICA	9	90.0	25.98	3.2	95.3	100.0
SCOLECOLEPIDES VIRIDIS	7	70.0	25.98	2.5	97.8	75.0
TENDIPEDIDAE	4	40.0	14.14	1.4	99.3	75.0
LEPTOCHEIRUS PLUMULOSUS	1	10.0	8.66	.4	99.6	25.0
CYATHURA POLITA	1	10.0	8.66	.4	100.0	25.0
TOTALS	277	2770.0	534.67			

CHALK POINT BENTHIC STUDIES
STATION 10

0.5 MM SCREEN

NOVEMBER 1979
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
COROPHIUM SP.	13	130.0	101.37	31.0	31.0	50.0
OLIGOCHAETE A	13	130.0	16.58	31.0	61.9	100.0
TENDIPEDIDAE	11	110.0	16.58	26.2	88.1	100.0
SCOLECOLEPIDES VIRIDIS	3	30.0	8.66	7.1	95.2	75.0
OLIGOCHAETE B	2	20.0	17.32	4.8	100.0	25.0
TOTALS	42	420.0	121.24			

CHALK POINT BENTHIC STUDIES
STATION 3

0.5 MM SCREEN

JANUARY 1980
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
LEPTOCHEIRUS PLUMULOSUS	93	930.0	163.94	24.3	24.3	100.0
HETEROMASTUS FILIFORMIS	85	850.0	163.32	22.2	46.5	100.0
OLIGOCHAETE A	79	790.0	130.67	20.6	67.1	100.0
MACOMA BALTHICA	47	470.0	66.90	12.3	79.4	100.0
CYATHURA POLITA	25	250.0	32.79	6.5	85.9	100.0
MACOMA PHENAX	18	180.0	41.23	4.7	90.6	100.0
COROPHIUM SP.	11	110.0	84.11	2.9	93.5	50.0
OLIGOCHAETE B	9	90.0	38.41	2.3	95.8	75.0
MYA ARENARIA	4	40.0	20.00	1.0	96.9	50.0
STREBLOSPIO BENEDICTI	3	30.0	16.58	.8	97.7	50.0
SCOLECOLEPIDES VIRIDIS	3	30.0	16.58	.8	98.4	50.0
MELITA NITIDA	2	20.0	17.32	.5	99.0	25.0
UNIDENTIFIED NEMERTEAN	2	20.0	10.00	.5	99.5	50.0
EDOTEA TRILOBA	1	10.0	8.66	.3	99.7	25.0
RANGIA CUNEATA	1	10.0	8.66	.3	100.0	25.0
TOTALS	383	3830.0	476.10			

CHALK POINT BENTHIC STUDIES
STATION 5

0.5 MM SCREEN

JANUARY 1980
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
OLIGOCHAETE A	143	1430.0	115.22	52.0	52.0	100.0
MACOMA BALTHICA	70	700.0	131.53	25.5	77.5	100.0
LEPTOCHEIRUS PLUMULOSUS	23	230.0	57.23	8.4	85.9	100.0
OLIGOCHAETE B	12	120.0	54.77	4.4	90.2	75.0
METEROMASTUS FILIFORMIS	11	110.0	8.66	4.0	94.2	100.0
NEREIS SUCCINEA	4	40.0	14.14	1.5	95.6	75.0
STREBLOSPIO BENEDICTI	3	30.0	16.58	1.1	96.7	50.0
SCOLECOLEPIDES VIRIDIS	3	30.0	16.58	1.1	97.8	50.0
COROPHIUM SP.	2	20.0	17.32	.7	98.5	25.0
MACOMA PHENAX	2	20.0	10.00	.7	99.3	50.0
CYATHURA POLITA	1	10.0	8.66	.4	99.6	25.0
UNIDENTIFIED NEMERTEAN	1	10.0	8.66	.4	100.0	25.0
TOTALS	275	2750.0	291.33			

CHALK POINT BENTHIC STUDIES
STATION 41

0.5 MM SCREEN

JANUARY 1980
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
OLIGOCHAETE A	112	1120.0	237.91	69.6	69.6	100.0
MACOMA BALTHICA	23	230.0	47.70	14.3	83.9	100.0
HETEROMASTUS FILIFORMIS	10	100.0	22.36	6.2	90.1	100.0
OLIGOCHAETE B	7	70.0	16.58	4.3	94.4	100.0
CYATHURA POLITA	5	50.0	16.58	3.1	97.5	75.0
CHIRIDOTEA ALMYRA	1	10.0	8.66	.6	98.1	25.0
SCOLECOLEPIDES VIRIDIS	1	10.0	8.66	.6	98.8	25.0
NEREIS SUCCINEA	1	10.0	8.66	.6	99.4	25.0
UNIDENTIFIED NEMERTEAN	1	10.0	8.66	.6	100.0	25.0
TOTALS	161	1610.0	321.05			

CHALK POINT BENTHIC STUDIES
STATION 8

0.5 MM SCREEN

JANUARY 1980
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
OLIGOCHAETE A	1115	11150.0	2718.58	94.3	94.3	100.0
SCOLECOLEPIDES VIRIDIS	30	300.0	99.50	2.5	96.9	75.0
MACOMA BALTHICA	20	200.0	81.24	1.7	98.6	100.0
OLIGOCHAETE B	7	70.0	60.62	.6	99.2	25.0
TENDIPEDIDAE	4	40.0	24.49	.3	99.5	50.0
CYATHURA POLITA	3	30.0	16.58	.3	99.7	50.0
LEPTOCHEIRUS PLUMULOSUS	1	10.0	8.66	.1	99.8	25.0
MACOMA PHENAX	1	10.0	8.66	.1	99.9	25.0
UNIDENTIFIED NEMERTEAN	1	10.0	8.66	.1	100.0	25.0
TOTALS	1182	11820.0	2571.59			

CHALK POINT BENTHIC STUDIES
STATION 9

0.5 MM SCREEN

JANUARY 1980
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
OLIGOCHAETE A	195	1950.0	646.43	91.1	91.1	100.0
SCOLECOLEPIDES VIRIDIS	11	110.0	21.79	5.1	96.3	100.0
TENDIPEDIDAE	5	50.0	21.79	2.3	98.6	75.0
CYATHURA POLITA	1	10.0	8.66	.5	99.1	25.0
MACOMA PHENAX	1	10.0	8.66	.5	99.5	25.0
OLIGOCHAETE B	1	10.0	8.66	.5	100.0	25.0
TOTALS	214	2140.0	670.75			

CHALK POINT BENTHIC STUDIES
STATION 10

0.5 MM SCREEN

JANUARY 1980
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
TENDIPEDIDAE	5	50.0	25.98	27.8	27.8	50.0
CYATHURA POLITA	4	40.0	24.49	22.2	50.0	50.0
OLIGOCHAETE A	3	30.0	16.58	16.7	66.7	50.0
OLIGOCHAETE B	2	20.0	10.00	11.1	77.8	50.0
POLYDORA SP.	2	20.0	10.00	11.1	88.9	50.0
HYPANIOLA GRAYI	1	10.0	8.66	5.6	94.4	25.0
SCOLECOLEPIDES VIRIDIS	1	10.0	8.66	5.6	100.0	25.0
TOTALS	18	180.0	75.50			

CHALK POINT BENTHIC STUDIES
STATION 3

0.5 MM SCREEN

MARCH 1980

TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
LEPTOCHEIRUS PLUMULOSUS	98	980.0	525.83	36.0	36.0	100.0
MACOMA BALTHICA	67	670.0	53.62	24.6	60.7	100.0
HETEROMASTUS FILIFORMIS	38	380.0	22.36	14.0	74.6	100.0
SCOLECOLEPIDES VIRIDIS	20	200.0	50.99	7.4	82.0	100.0
CYATHURA POLITA	13	130.0	29.58	4.8	86.8	100.0
MACOMA PHENAX	8	80.0	24.49	2.9	89.7	100.0
OLIGOCHAETE A	7	70.0	29.58	2.6	92.3	75.0
COROPHIUM SP.	6	60.0	22.36	2.2	94.5	75.0
OLIGOCHAETE 9	6	60.0	30.00	2.2	96.7	75.0
UNIDENTIFIED NEMERTEAN	6	60.0	17.32	2.2	98.9	100.0
NEREIS SUCCINEA	2	20.0	17.32	.7	99.6	25.0
RANGIA CUNEATA	1	10.0	8.66	.4	100.0	25.0
TOTALS	272	2720.0	517.69			

CHALK POINT BENTHIC STUDIES

STATION 5

0.5 MM SCREEN

MARCH 1980

TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
MACOMA BALTHICA	69	690.0	96.31	22.9	22.9	100.0
OLIGOCHAETE A	68	680.0	131.91	22.6	45.5	100.0
SCOLECOLEPIDES VIRIDIS	67	670.0	159.61	22.3	67.8	100.0
LEPTOCHEIRUS PLUMULOSUS	43	430.0	65.38	14.3	82.1	100.0
HETEROMASTUS FILIFORMIS	20	200.0	31.24	6.6	88.7	100.0
OLIGOCHAETE 3	9	90.0	29.58	3.0	91.7	75.0
COROPHIUM SP.	8	80.0	37.42	2.7	94.4	75.0
UNIDENTIFIED NEMERTEAN	6	60.0	17.32	2.0	96.3	75.0
NEREIS SUCCINEA	5	50.0	21.79	1.7	98.0	75.0
CYATHURA POLITA	2	20.0	17.32	.7	98.7	25.0
MACOMA PHENAX	2	20.0	10.00	.7	99.3	50.0
GAMMARUS SP.	1	10.0	8.66	.3	99.7	25.0
EDOTEA TRILOBA	1	10.0	8.66	.3	100.0	25.0
TOTALS	301	3010.0	149.92			

CHALK POINT BENTHIC STUDIES
STATION 41 0.5 MM SCREEN

MARCH 1980
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
SCOLECOLEPIDES VIRIDIS	221	2210.0	819.19	48.3	48.3	100.0
OLIGOCHAETE A	153	1530.0	597.56	33.4	81.7	100.0
MACOMA BALTHICA	38	380.0	57.45	8.3	90.0	100.0
LEPTOCHEIRUS PLUMULOSUS	9	90.0	35.71	2.0	91.9	75.0
HETEROMASTUS FILIFORMIS	9	90.0	35.71	2.0	93.9	75.0
CYATHURA POLITA	8	80.0	24.49	1.7	95.6	100.0
COROPHIUM SP.	5	50.0	32.79	1.1	96.7	50.0
OLIGOCHAETE B	4	40.0	24.49	.9	97.6	50.0
RANGIA CUNEATA	3	30.0	8.66	.7	98.3	75.0
EDOTEA TRILOBA	2	20.0	17.32	.4	98.7	25.0
UNIDENTIFIED NEMERTEAN	2	20.0	17.32	.4	99.1	25.0
MONOCULODES EDWARDSI	1	10.0	8.66	.2	99.3	25.0
GAMMARUS SP.	1	10.0	8.66	.2	99.6	25.0
MACOMA PHENAX	1	10.0	8.66	.2	99.8	25.0
NEREIS SUCCINEA	1	10.0	8.66	.2	100.0	25.0
TOTALS	458	4580.0	1220.29			

CHALK POINT BENTHIC STUDIES
STATION 41

0.5 MM SCREEN

MARCH 1980
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
SCOLECOLEPIDES VIRIDIS	221	2210.0	819.19	48.3	48.3	100.0
OLIGOCHAETE A	153	1530.0	597.56	33.4	81.7	100.0
MACOMA BALTHICA	38	380.0	57.45	8.3	90.0	100.0
LEPTOCHEIRUS PLUMULOSUS	9	90.0	35.71	2.0	91.9	75.0
HETEROMASTUS FILIFORMIS	9	90.0	35.71	2.0	93.9	75.0
CYATHURA POLITA	8	80.0	24.49	1.7	95.6	100.0
COROPHIUM SP.	5	50.0	32.79	1.1	96.7	50.0
OLIGOCHAETE B	4	40.0	24.49	.9	97.6	50.0
RANGIA CUNEATA	3	30.0	8.66	.7	98.3	75.0
EDOTEA TRILOBA	2	20.0	17.32	.4	98.7	25.0
UNIDENTIFIED NEMERTEAN	2	20.0	17.32	.4	99.1	25.0
MONOCULODES EDWARDSI	1	10.0	8.66	.2	99.3	25.0
GAMMARUS SP.	1	10.0	8.66	.2	99.6	25.0
MACOMA PHENAX	1	10.0	8.66	.2	99.8	25.0
NEREIS SUCCINEA	1	10.0	8.66	.2	100.0	25.0
TOTALS	458	4580.0	1220.29			

CHALK POINT BENTHIC STUDIES
STATION 10

0.5 MM SCREEN

MARCH 1980
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
SCOLECOLEPIDES VIRIDIS	39	390.0	65.38	49.4	49.4	100.0
OLIGOCHAETE A	35	350.0	80.47	44.3	93.7	100.0
TENDIPEDIDAE	3	30.0	16.58	3.8	97.5	50.0
LEPTOCHEIRUS PLUMULOSUS	1	10.0	8.66	1.3	98.7	25.0
OLIGOCHAETE B	1	10.0	8.66	1.3	100.0	25.0
TOTALS	79	790.0	158.98			

CHALK POINT BENTHIC STUDIES
STATION 10

0.5 MM SCREEN

MARCH 1980
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
SCOLECOLEPIDES VIRIDIS	39	390.0	65.38	49.4	49.4	100.0
OLIGOCHAETE A	35	350.0	80.47	44.3	93.7	100.0
TENDIPEDIDAE	3	30.0	16.58	3.8	97.5	50.0
LEPTOCHEIRUS PLUMULOSUS	1	10.0	8.66	1.3	98.7	25.0
OLIGOCHAETE B	1	10.0	8.66	1.3	100.0	25.0
TOTALS	79	790.0	158.98			

CHALK POINT BENTHIC STUDIES
STATION 3

0.5 MM SCREEN

MAY 1980

TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
SCOLECOLEPIDES VIRIDIS	183	1830.0	306.06	32.0	32.0	100.0
MACOMA BALTHICA	92	920.0	37.42	16.1	48.1	100.0
LEPTOCHEIRUS PLUMULOSUS	91	910.0	311.25	15.9	64.0	100.0
HETEROMASTUS FILIFORMIS	56	560.0	119.16	9.8	73.8	100.0
COROPHIUM SP.	45	450.0	216.51	7.9	81.6	100.0
NEREIS SUCCINEA	27	270.0	38.41	4.7	86.4	100.0
CYATHURA POLITA	21	210.0	55.45	3.7	90.0	100.0
OLIGOCHAETE A	21	210.0	68.37	3.7	93.7	100.0
MACOMA PHENAX	9	90.0	29.58	1.6	95.3	75.0
MELITA NITIDA	7	70.0	29.58	1.2	96.5	75.0
GAMMARUS SP.	5	50.0	21.79	.9	97.4	75.0
OLIGOCHAETE B	4	40.0	24.49	.7	98.1	50.0
POLYDORA SP.	4	40.0	14.14	.7	98.8	75.0
MYA ARENARIA	2	20.0	10.00	.3	99.1	50.0
UNIDENTIFIED NEMERTEAN	2	20.0	10.00	.3	99.5	50.0
NEOMYSIS AMERICANA	1	10.0	8.66	.2	99.7	25.0
RANGIA CUNEATA	1	10.0	8.66	.2	99.8	25.0
STREBLOSPIO BENEDICTI	1	10.0	8.66	.2	100.0	25.0
TOTALS	572	5720.0	607.78			

CHALK POINT BENTHIC STUDIES
STATION 5

0.5 MM SCREEN

MAY 1980
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
MACOMA BALTHICA	123	1230.0	69.82	28.5	28.5	100.0
LEPTOCHEIRUS PLUMULOSUS	121	1210.0	333.28	28.1	56.6	100.0
OLIGOCHAETE A	92	920.0	209.76	21.3	78.0	100.0
HETEROMASTUS FILIFORMIS	46	460.0	41.23	10.7	88.6	100.0
OLIGOCHAETE B	23	230.0	97.34	5.3	94.0	75.0
SCOLECOLEPIDES VIRIDIS	13	130.0	29.58	3.0	97.0	100.0
NEREIS SUCCINEA	4	40.0	14.14	.9	97.9	75.0
UNIDENTIFIED NEMERTEAN	4	40.0	14.14	.9	98.8	75.0
GAMMARUS SP.	2	20.0	10.00	.5	99.3	50.0
TENDIPEDIDAE	1	10.0	8.66	.2	99.5	25.0
CYATHURA POLITA	1	10.0	8.66	.2	99.8	25.0
RANGIA CUNEATA	1	10.0	8.66	.2	100.0	25.0
TOTALS	431	4310.0	171.68			

CHALK POINT BENTHIC STUDIES
STATION 41

0.5 MM SCREEN

MAY 1980

TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
LEPTOCHEIRUS PLUMULOSUS	426	4260.0	1088.90	57.3	57.3	100.0
SCOLECOLEPIDES VIRIDIS	141	1410.0	650.60	19.0	76.2	100.0
MACOMA BALTHICA	53	580.0	43.59	7.8	84.0	100.0
GAMMARUS SP.	55	550.0	136.66	7.4	91.4	100.0
OLIGOCHAETE A	40	400.0	116.62	5.4	96.8	100.0
HETEROMASTUS FILIFORMIS	10	100.0	33.17	1.3	98.1	100.0
OLIGOCHAETE B	9	90.0	29.58	1.2	99.3	75.0
CYATHURA POLITA	2	20.0	10.00	.3	99.6	50.0
RANGIA CUNEATA	1	10.0	8.66	.1	99.7	25.0
MACOMA PHENAX	1	10.0	8.66	.1	99.9	25.0
UNIDENTIFIED NEMERTEAN	1	10.0	8.66	.1	100.0	25.0
TOTALS	744	7440.0	1924.84			

CHALK POINT BENTHIC STUDIES
STATION 8

0.5 MM SCREEN

MAY 1980

TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
SCOLECOLEPIDES VIRIDIS	373	3730.0	916.99	48.9	48.9	100.0
LEPTOCHEIRUS PLUMULOSUS	147	1470.0	317.92	19.3	68.2	100.0
OLIGOCHAETE A	138	1380.0	248.80	18.1	86.2	100.0
OLIGOCHAETE B	36	360.0	61.64	4.7	91.0	100.0
MACOMA BALTHICA	23	230.0	58.95	3.0	94.0	100.0
GAMMARUS SP.	18	180.0	50.00	2.4	96.3	100.0
TENDIPEDIDAE	10	100.0	33.17	1.3	97.6	75.0
CYATHURA POLITA	7	70.0	8.66	.9	98.6	100.0
RANGIA CUNEATA	3	30.0	16.58	.4	99.0	50.0
NEOMYSIS AMERICANA	2	20.0	17.32	.3	99.2	25.0
MACOMA PHENAX	2	20.0	10.00	.3	99.5	50.0
HETEROMASTUS FILIFORMIS	2	20.0	10.00	.3	99.7	50.0
UNIDENTIFIED NEMERTEAN	2	20.0	17.32	.3	100.0	25.0
TOTALS	763	7630.0	864.45			

CHALK POINT BENTHIC STUDIES
STATION 9

0.5 MM SCREEN

MAY 1980
TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
SCOLECOLEPIDES VIRIDIS	194	1940.0	414.85	62.8	62.8	100.0
OLIGOCHAETE A	47	470.0	110.79	15.2	78.0	100.0
LEPTOCHEIRUS PLUMULOSUS	33	330.0	71.24	10.7	88.7	100.0
OLIGOCHAETE B	10	100.0	17.32	3.2	91.9	100.0
GAMMARUS SP.	8	80.0	14.14	2.6	94.5	100.0
MACOMA BALTHICA	5	50.0	21.79	1.6	96.1	75.0
UNIDENTIFIED NEMERTEAN	4	40.0	14.14	1.3	97.4	75.0
TENDIPEDIDAE	3	30.0	16.58	1.0	98.4	50.0
RANGIA CUNEATA	2	20.0	10.00	.6	99.0	50.0
EDOTEA TRILOBA	1	10.0	8.66	.3	99.4	25.0
CYATHURA POLITA	1	10.0	8.66	.3	99.7	25.0
MACOMA PHENAX	1	10.0	8.66	.3	100.0	25.0
TOTALS	309	3090.0	509.78			

CHALK POINT BENTHIC STUDIES
STATION 9

0.5 MM SCREEN

MAY 1980

TOTALS ALL REPLICATES

SPECIES NAME	NUMBER OF INDIVIDUALS IN SAMPLES	MEAN NUMBER OF INDIVIDUALS PER SQ. M	STANDARD ERROR OF THE MEAN	PERCENT FAUNA	CUMULATIVE PERCENT	FREQUENCY OF OCCURRENCE IN SAMPLES
SCOLECOLEPIDES VIRIDIS	194	1940.0	414.85	62.8	62.8	100.0
OLIGOCHAETE A	47	470.0	110.79	15.2	78.0	100.0
LEPTOCHEIRUS PLUMULOSUS	33	330.0	71.24	10.7	88.7	100.0
OLIGOCHAETE B	10	100.0	17.32	3.2	91.9	100.0
GAMMARUS SP.	8	80.0	14.14	2.6	94.5	100.0
MACOMA BALTHICA	5	50.0	21.79	1.6	96.1	75.0
UNIDENTIFIED NEMERTEAN	4	40.0	14.14	1.3	97.4	75.0
TENDIPEDIDAE	3	30.0	16.58	1.0	98.4	50.0
RANGIA CUNEATA	2	20.0	10.00	.6	99.0	50.0
EDDTEA TRILOBA	1	10.0	8.66	.3	99.4	25.0
CYATHURA POLITA	1	10.0	8.66	.3	99.7	25.0
MACOMA PHENAX	1	10.0	8.66	.3	100.0	25.0
TOTALS	309	3090.0	509.78			

Table 1. Physical data collected during November 1978 by the benthic community study

Sample Location	Depth (m)	Temp. (°C)	Dissolved Oxygen Concentration (ppm)	Water Column Salinity (ppt)	Interstitial Salinity (ppt)	Moisture Content (% sample total weight)	Silt-Clay Content (% sample dry weight)	Organic Content Combustion at 500°C (% sample dry weight)	Organic Content - Wet Oxidation (% sample dry weight)
Station 5	S	8.54	-	11.68	10.5	60.8	72.6	8.8	2.4
	1	8.56	-	11.92					
	2	8.45	-	12.06					
	2.5	8.45	-	12.21					
Station 6	S	8.18	-	11.82	10.0	62.0	83.6	9.9	2.2
	1	8.56	-	11.65					
	2	8.47	-	11.82					
	3	8.48	-	12.11					
	3.5	8.47	-	12.10					
Station 7	S	8.30	-	9.40	8.5	60.3	68.6	8.8	2.0
	1	9.33	-	9.75					
	2	9.33	-	9.92					
	3	9.16	-	9.75					
Station 8	S	8.30	-	9.56	8.0	65.2	88.4	11.0	2.7
	1	8.48	-	9.80					
	2	8.65	-	10.25					
	3	8.78	-	10.35					
	3.5	8.75	-	10.35					

Table 2. Physical data collected during December 1978 by the benthic community study

Sample Location	Depth (m)	Temp. (°C)	Dissolved Oxygen Concentration (ppm)	Water Column Salinity (ppt)	Interstitial Salinity (ppt)	Moisture Content (% sample total weight)	Silt-Clay Content (% sample dry weight)	Organic Content Combustion at 500°C (% sample dry weight)	Organic Content - Wet Oxidation (% sample dry weight)
Station 5	S	4.05	11.2	12.06	9.5	62.7	82.2	10.2	2.2
	1	4.05	11.3	9.42					
	2	5.13	10.8	11.80					
	3	5.88	10.5	12.92					
Station 6	S	2.93	13.1	6.83	8.0	62.2	86.0	10.5	1.8
	1	2.93	13.2	6.80					
	2	4.34	11.2	10.37					
	3	4.22	11.2	9.70					
Station 7	S	5.52	11.1	7.70	7.5	61.0	69.4	8.8	2.0
	1	5.86	10.6	7.92					
	2	6.26	10.8	7.92					
	2.5	4.87	10.5	8.30					
Station 8	S	3.42	11.6	4.52	6.5	66.9	90.8	11.4	2.45
	1	3.44	11.5	4.98					
	2	4.83	11.1	6.57					
	2.5	4.96	10.5	8.21					

Table 3. Physical data collected during January 1979 by the benthic community study

Sample Location	Depth (m)	Temp. (°C)	Dissolved Oxygen Concentration (ppm)	Water Column Salinity (ppt)	Interstitial Salinity (ppt)	Moisture Content (% sample total weight)	Silt-Clay Content (% sample dry weight)	Organic Content Combustion at 500°C (% sample dry weight)	Organic Content - Wet Oxidation (% sample dry weight)
Station 5	S	2.50	12.8	5.43	7.5	64.5	95.4	11.7	2.0
	1	2.50	12.6	5.40					
	2	2.39	12.5	5.40					
	3	2.39	12.5	5.29					
Station 6	S	2.14	13.5	4.48	6.5	61.0	87.0	10.2	1.9
	1	2.32	13.3	4.26					
	2	2.32	13.2	4.63					
	3	1.97	13.2	4.63					
Station 7	S	2.61	13.5	1.10	4.0	59.3	73.6	9.2	1.9
	1	2.61	13.4	1.20					
	2	2.69	13.4	1.20					
	3	2.75	13.4	1.15					
Station 8	S	2.75	13.7	0.82	4.0	65.4	91.2	10.6	2.4
	1	2.75	13.6	0.79					
	2	2.79	13.5	0.93					
	3	2.79	13.4	0.84					

Table 4. Physical data collected during February 1979 by the benthic community study

Sample Location	Depth (m)	Temp. (°C)	Dissolved Oxygen Concentration (ppm)	Water Column Salinity (ppt)	Interstitial Salinity (ppt)	Moisture Content (% sample total weight)	Silt-Clay Content (% sample dry weight)	Organic Content Combustion at 500°C (% sample dry weight)	Organic Content - Wet Oxidation (% sample dry weight)
Station 5	S	1.05	11.6	0.76	2.0	67.1	79.0	10.1	2.0
	1	1.05	11.6	0.84					
	2	0.94	11.5	1.88					
	3	0.94	11.5	4.38					
Station 6	S	1.11	11.7	1.32	2.0	67.5	93.2	11.5	2.2
	1	1.11	11.6	1.52					
	2	1.04	11.6	1.67					
	3	1.04	11.6	1.58					
	3.5	0.93	11.5	2.01					
Station 7	S	1.99	11.6	0.06	2.0	65.5	80.6	9.9	2.3
	1	1.81	11.5	0.17					
	2	1.74	11.4	0.11					
	2.5	1.65	11.4	0.15					
Station 8	S	1.24	11.7	0.15	2.0	69.3	96.0	11.3	3.0
	1	1.20	11.6	0.13					
	2	1.20	11.6	0.04					
	3	1.09	11.6	0.14					

Table 5. Physical data collected during March 1979 by the benthic community study

Sample Location	Depth (m)	Temp. (°C)	Dissolved Oxygen Concentration (ppm)	Water Column Salinity (ppt)	Interstitial Salinity (ppt)	Moisture Content (% sample total weight)	Silt-Clay Content (% sample dry weight)	Organic Content Combustion at 500°C (% sample dry weight)	Organic Content - Wet Oxidation (% sample dry weight)
Station 5	S	11.25	8.0	2.9	4.0	66.7	93.2	10.1	2.1
	1	11.25	8.0	2.9					
	2	11.00	8.0	3.0					
	3	11.00	7.9	3.0					
Station 6	S	11.00	8.3	2.7	2.5	68.1	87.0	11.5	2.1
	1	11.00	8.0	2.9					
	2	11.00	8.1	2.8					
	3	10.80	8.3	3.2					
Station 7	S	11.25	7.5	0.5	1.5	68.3	88.2	9.9	2.1
	1	11.25	7.5	0.5					
	2	11.25	7.5	0.6					
	3	11.25	7.5	0.9					
Station 8	S	11.25	7.5	0.5	2.0	71.5	94.0	11.3	3.1
	1	11.25	7.5	0.5					
	2	11.25	7.5	0.5					
	3	11.00	7.2	0.6					

Table 6. Physical data collected during April 1979 by the benthic community study

Sample Location	Depth (m)	Temp. (°C)	Dissolved Oxygen Concentration (ppm)	Water Column Salinity (ppt)	Interstitial Salinity (ppt)	Moisture Content (% sample total weight)	Silt-Clay Content (% sample dry weight)	Organic Content Combustion at 500°C (% sample dry weight)	Organic Content - Wet Oxidation (% sample dry weight)
Station 5	S	15.33	14.0	4.22	2.5	67.0	89.6	11.2	2.6
	1	15.33	14.0	4.17					
	2	15.16	13.6	4.41					
	3	15.16	13.5	4.24					
Station 6	S	15.31	12.9	3.76	2.0	67.0	90.0	10.9	2.0
	1	15.31	13.1	3.83					
	2	15.13	13.2	3.96					
	3	15.06	13.0	4.05					
Station 7	S	15.29	12.7	1.59	1.5	64.7	74.6	9.8	1.6
	1	15.19	12.4	1.58					
	2	15.31	12.1	1.72					
	2.5	15.62	11.9	2.13					
Station 8	S	15.14	12.3	1.79	2.0	65.1	91.8	11.5	2.4
	1	15.19	12.1	1.89					
	2	15.31	11.9	1.98					
	2.5	15.34	12.0	2.17					

Table 7. Physical data collected during May 1979 by the benthic community study

Sample Location	Depth (m)	Temp. (°C)	Dissolved Oxygen Concentration (ppm)	Water Column Salinity (ppt)	Interstitial Salinity (ppt)	Moisture Content (% sample total weight)	Silt-Clay Content (% sample dry weight)	Organic Content Combustion at 500°C (% sample dry weight)	Organic Content - Wet Oxidation (% sample dry weight)
Station 5	S	21.56	8.0	5.12	4.5	66.1	94.8	12.7	2.1
	1	21.30	7.6	5.16					
	2	21.42	7.4	5.23					
	3	21.42	7.1	5.20					
	4	21.42	7.1	5.26					
Station 6	S	21.35	7.6	5.02	4.0	63.4	92.4	11.9	1.6
	1	21.53	7.6	5.11					
	2	21.44	6.0	5.06					
	3	21.54	5.6	5.28					
Station 7	S	23.08	6.7	3.13	2.0	60.2	70.0	9.2	1.2
	1	22.90	6.4	3.13					
	2	22.68	6.3	3.02					
	3	22.10	6.1	2.96					
Station 8	S	21.83	7.4	2.54	2.0	65.6	90.8	11.8	2.3
	1	22.05	7.2	2.54					
	2	21.90	6.9	3.30					
	3	-	-	-					

Table 8. Physical data collected during July 1979 by the benthic community study

Sample Location	Depth (m)	Temp. (°C)	Dissolved Oxygen Concentration (ppm)	Water Column Salinity (ppt)	Interstitial Salinity (ppt)	Moisture Content (% sample total weight)	Silt-Clay Content (% sample dry weight)	Organic Content Combustion at 500°C (% sample dry weight)	Organic Content - Wet Oxidation (% sample dry weight)
Station 3	S	28.86	-	7.25	6.0	62.7	89.8	10.6	2.3
	1	29.06	-	7.25					
	2	28.60	-	7.45					
	3	27.83	-	7.66					
Station 5	S	28.78	-	6.95	4.0	69.2	91.8	13.2	1.5
	1	27.89	-	6.70					
	2	27.79	-	6.80					
	3	27.39	-	7.43					
Station 41	S	30.83	-	6.09	3.0	67.2	97.0	12.4	1.8
	1	30.15	-	6.45					
	2	28.91	-	6.33					
	-	-	-	-					
Station 8	S	29.95	-	5.42	3.5	73.6	94.4	13.5	2.5
	1	30.07	-	5.58					
	2	29.39	-	6.16					
	2.5	29.46	-	6.16					
Station 9	S	34.18	-	5.39	2.5	73.0	98.0	14.5	2.4
	1	33.03	-	5.35					
	2	30.29	-	5.59					
	3	29.60	-	5.75					
Station 10	S	31.25	-	3.12	1.5	74.3	97.2	14.2	2.5
	1	30.76	-	3.72					
	2	30.62	-	4.53					
	3	30.20	-	4.52					

Table 9. Physical data collected during September 1979 by the benthic community study

Sample Location	Depth (m)	Temp. (°C)	Dissolved Oxygen Concentration (ppm)	Water Column Salinity (ppt)	Interstitial Salinity (ppt)	Moisture Content (% sample total weight)	Silt-Clay Content (% sample dry weight)	Organic Content Combustion at 500°C (% sample dry weight)	Organic Content - Wet Oxidation (% sample dry weight)
Station 1	S	22.04	7.9	9.75	7.0	39.1	31.5	2.5	0.4
	1	22.04	7.7	10.57					
	2	22.16	7.0	10.42					
	3	22.04	7.0	10.50					
Station 2	S	20.52	9.6	7.77	5.0	23.7	3.7	0.8	0.1
	1	20.52	9.9	7.98					
	2	20.55	9.3	7.43					
	2.5	20.43	9.1	8.17					
Station 3	S	20.44	9.9	6.54	4.5	60.8	70.4	8.6	1.4
	1	20.59	10.2	6.65					
	2	20.44	10.4	6.68					
	3	21.39	6.4	6.38					
Station 4	S	21.78	8.4	7.45	6.0	31.3	17.6	2.5	0.5
	1	21.63	8.3	7.46					
	2	21.77	7.3	7.70					
	2.8	21.79	6.5	7.02					
Station 5	S	20.86	9.2	4.41	6.0	58.2	69.2	8.4	1.9
	1	20.86	9.1	4.61					
	2	20.75	8.1	5.06					
	3	20.75	7.0	5.34					
Station 41	S	20.32	9.4	1.23	3.5	67.7	95.2	10.7	2.3
	1	20.51	9.3	1.64					
	2	20.51	9.0	1.57					
	-	-	-	-					

Table 9. Continued

Sample Location	Depth (m)	Temp. (°C)	Dissolved Oxygen Concentration (ppm)	Water Column Salinity (ppt)	Interstitial Salinity (ppt)	Moisture Content (% sample total weight)	Silt-Clay Content (% sample dry weight)	Organic Content Combustion at 500°C (% sample dry weight)	Organic Content - Wet Oxidation (% sample dry weight)
Station 8	S	20.65	9.0	1.67	3.5	65.8	90.0	11.0	2.5
	1	20.74	8.9	1.72					
	2	22.44	8.6	1.47					
	2.5	22.44	8.3	2.74					
Station 9	S	20.09	8.8	0.57	2.0	71.5	96.8	13.7	2.4
	1	20.23	8.7	0.51					
	2	20.23	8.6	0.27					
	3	20.22	8.6	0.78					
Station 10	S	19.78	8.9	0	0.5	68.6	98.8	12.5	2.1
	1	19.96	8.8	0.31					
	2	19.96	8.6	0.10					
	2.5	19.84	8.8	0					
Station 11	S	19.42	8.0	0.13	0.5	73.3	96.2	13.4	3.0
	1	19.36	8.0	0					
	2	19.29	8.9	0.13					
	3	19.29	8.0	0					
	3.5	20.04	7.9	0.35					
Station 12	S	18.42	7.5	0	0	66.5	95.4	13.8	3.3
	1	18.42	7.3	0.05					
	2	18.23	7.4	0					
	3	18.24	7.3	0.15					
Station 22 Western Branch	S	17.28	7.2	0.05	0	43.0	94.0	8.9	1.6
	1	17.46	7.1	0					
	2	17.44	7.2	0					
	3	17.44	7.0	0.08					
	3.5	17.45	6.9	0					

Table 10. Physical data collected during November 1979 by the benthic community study

Sample Location	Depth (m)	Temp. (°C)	Dissolved Oxygen Concentration (ppm)	Water Column Salinity (ppt)	Interstitial Salinity (ppt)	Moisture Content (% sample total weight)	Silt-Clay Content (% sample dry weight)	Organic Content Combustion at 500°C (% sample dry weight)	Organic Content - Wet Oxidation (% sample dry weight)
Station 3	S	13.87	10.1	7.64	5.0	62.7	79.8	9.2	1.3
	1	13.79	10.0	7.25					
	2	13.35	9.9	8.55					
	3	13.49	9.0	7.01					
Station 5	S	13.28	10.2	6.73	2.5	72.4	98.0	13.5	2.6
	1	13.30	10.0	12.07					
	2	13.38	10.1	14.20					
	3	13.15	9.7	15.00					
Station 41	S	13.59	9.8	7.00	3.0	70.1	97.6	11.9	2.5
	1	11.85	9.6	14.09					
	2	13.95	9.8	11.69					
	2.5	13.62	9.3	8.31					
Station 8	S	12.26	10.0	5.56	2.5	69.4	93.8	12.3	3.1
	1	12.49	9.8	2.91					
	2	8.86	9.6	5.20					
	3	10.49	9.2	8.81					
Station 9	S	13.19	9.9	6.53	2.0	72.5	95.6	13.6	2.9
	1	13.07	9.7	6.82					
	2	13.58	9.7	5.76					
	3	13.58	9.6	9.15					
Station 10	S	10.20	10.0	0	0.5	73.3	93.2	11.7	3.8
	1	9.45	10.0	4.37					
	2	9.68	9.9	4.09					
	3	10.12	9.4	8.67					

Table 10. Physical data collected during November 1979 by the benthic community study

Sample Location	Depth (m)	Temp. (°C)	Dissolved Oxygen Concentration (ppm)	Water Column Salinity (ppt)	Interstitial Salinity (ppt)	Moisture Content (% sample total weight)	Silt-Clay Content (% sample dry weight)	Organic Content Combustion at 500°C (% sample dry weight)	Organic Content - Wet Oxidation (% sample dry weight)
Station 3	S	13.87	10.1	7.64	5.0	62.7	79.8	9.2	1.3
	1	13.79	10.0	7.25					
	2	13.35	9.9	8.55					
	3	13.49	9.0	7.01					
Station 5	S	13.28	10.2	6.73	2.5	72.4	98.0	13.5	2.6
	1	13.30	10.0	12.07					
	2	13.38	10.1	14.20					
	3	13.15	9.7	15.00					
Station 41	S	13.59	9.8	7.00	3.0	70.1	97.6	11.9	2.5
	1	11.85	9.6	14.09					
	2	13.95	9.8	11.69					
	2.5	13.62	9.3	8.31					
Station 8	S	12.26	10.0	5.56	2.5	69.4	93.8	12.3	3.1
	1	12.49	9.8	2.91					
	2	8.86	9.6	5.20					
	3	10.49	9.2	8.81					
Station 9	S	13.19	9.9	6.53	2.0	72.5	95.6	13.6	2.9
	1	13.07	9.7	6.82					
	2	13.58	9.7	5.76					
	3	13.58	9.6	9.15					
Station 10	S	10.20	10.0	0	0.5	73.3	93.2	11.7	3.8
	1	9.45	10.0	4.37					
	2	9.68	9.9	4.09					
	3	10.12	9.4	8.67					

Table 12. Physical data collected during March 1980 by the benthic community study

Sample Location	Depth (m)	Temp. (°C)	Dissolved Oxygen Concentration (ppm)	Water Column Salinity (ppt)	Interstitial Salinity (ppt)	Moisture Content (% sample total weight)	Silt-Clay Content (% sample dry weight)	Organic Content Combustion at 500°C (% sample dry weight)	Organic Content - Wet Oxidation (% sample dry weight)
Station 3	S	7.61	13.5	7.61	8.0	61.7	81.8	10.2	2.2
	1	7.13	12.6	10.27					
	2	6.44	12.5	11.14					
	3	6.10	8.4	12.36					
Station 5	S	7.19	12.6	8.28	8.0	64.5	77.6	10.0	1.7
	1	6.49	11.9	10.68					
	2	6.00	11.8	12.29					
	-	-	-	-					
Station 41	S	7.70	11.8	8.00	5.0	64.3	93.8	11.1	2.3
	1	7.45	11.6	8.42					
	2	7.00	11.2	9.60					
	2.5	7.00	10.8	9.68					
Station 8	S	7.62	11.8	6.55	4.0	69.5	90.6	12.5	3.3
	1	7.62	11.5	6.89					
	2	7.78	11.2	7.50					
	3	7.50	10.8	8.38					
Station 9	S	7.93	11.5	4.83	3.5	73.2	98.2	13.8	3.5
	1	7.49	11.8	7.25					
	2	7.53	10.4	8.07					
	3.5	7.53	10.2	8.43					
Station 10	S	8.89	8.8	3.58	1.5	67.9	96.4	10.3	3.7
	1	8.15	8.6	4.52					
	2	7.90	8.6	5.86					
	3	7.75	8.5	6.31					

Table 13. Physical data collected during May 1980 by the benthic community study

Sample Location	Depth (m)	Temp. (°C)	Dissolved Oxygen Concentration (ppm)	Water Column Salinity (ppt)	Interstitial Salinity (ppt)	Moisture Content (% sample total weight)	Silt-Clay Content (% sample dry weight)	Organic Content Combustion at 500°C (% sample dry weight)	Organic Content - Wet Oxidation (% sample dry weight)
Station 3	S	18.09	10.0	6.49	6.0	55.6	60.8	7.0	1.2
	1	18.09	9.4	6.80					
	2	17.82	8.2	7.13					
	-	-	-	-					
Station 5	S	17.80	7.2	5.88	5.5	73.0	89.2	12.4	2.9
	1	17.80	7.5	6.87					
	2	16.45	5.3	8.56					
	-	-	-	-					
Station 41	S	18.93	8.3	4.64	2.5	70.1	92.8	11.8	2.7
	1	18.66	8.4	4.89					
	2	18.83	8.4	5.11					
	-	-	-	-					
Station 8	S	19.26	8.7	3.50	2.5	69.1	89.4	11.6	3.4
	1	19.34	8.6	3.45					
	2	19.23	8.1	4.26					
	3	19.23	8.1	4.46					
Station 9	S	19.74	8.4	2.58	2.0	70.0	92.4	12.0	3.6
	1	19.88	8.5	2.53					
	2	20.11	8.4	2.74					
	3	20.24	8.3	2.79					
Station 10	S	19.52	8.0	0.60	1.0	71.8	95.8	11.9	3.6
	1	19.67	8.1	0.66					
	2	19.41	7.8	0.70					
	-	-	-	-					

DO NOT CIRCULATE

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